LilyPond

The music typesetter

Contributor's Guide

The LilyPond development team

This manual documents contributing to LilyPond version 2.26.0. It discusses technical issues and policies that contributors should follow.

This manual is not intended to be read sequentially; new contributors should only read the sections which are relevant to them. For more information about different jobs, see Section 1.1 [Help us], page 1.

For more information about how this manual fits with the other documentation, or to read this manual in other formats, see Section "Manuals" in *General Information*.

If you are missing any manuals, the complete documentation can be found at `https://lilypond.org/`.

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For LilyPond version 2.26.0

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1 Introduction to contributing

This chapter presents a quick overview how people can help LilyPond.

1.1 Help us

We need you!

Thank you for your interest in helping us – we would love to see you get involved! Your contribution will help a large group of users make beautifully typeset music.

Even working on small tasks can have a big impact: taking care of them allows experienced developers to work on advanced tasks instead of spending time on those simple tasks.

For a multi-faceted project like LilyPond, sometimes it's tough to know where to begin. In addition to the avenues proposed below, you can send an e-mail to the `lilypond-devel@gnu.org` (`https://lists.gnu.org/mailman/listinfo/lilypond-devel`) mailing list, and we'll help you to get started.

Simple tasks

No programming skills required!

- Mailing list support: answer questions from fellow users. (This may entail helping them navigate the online documentation; in such cases it may sometimes be appropriate to point them to version-agnostic URL paths such as '`latest`' (`https://lilypond.org/doc/latest/Documentation/notation/`) or '`stable`' (`https://lilypond.org/doc/stable/Documentation/notation/`), which are automatically redirected.)
- Bug reporting: help users create proper Section "Bug reports" in *General Information*, and/or join the Bug Squad to organize Section "Issues" in *Contributor's Guide*.
- Documentation: small changes can be proposed by following the guidelines for Section "Documentation suggestions" in *Contributor's Guide*.
- LilyPond Wiki: create and fix snippets following the guidelines in Section "Adding and editing snippets" in *Contributor's Guide*.
- Discussions, reviews, and testing: the developers often ask for feedback about new documentation, potential syntax changes, and testing new features. Please contribute to these discussions!

Advanced tasks

These jobs generally require that you have the source code and can compile LilyPond.

> **Note:** We suggest that contributors using Windows or macOS do **not** attempt to set up their own development environment; instead, use Lilydev as discussed in Section "Quick start" in *Contributor's Guide*.

Contributors using Linux or FreeBSD may also use Lilydev, but if they prefer their own development environment, they should read Section "Working with source code" in *Contributor's Guide*, and Section "Compiling" in *Contributor's Guide*.

Begin by reading Section "Summary for experienced developers" in *Contributor's Guide*.

- Documentation: for large changes, see Section "Documentation work" in *Contributor's Guide*.
- Website: the website is built from the normal documentation source. See the info about documentation, and also Section "Website work" in *Contributor's Guide*.

- Translations: see Section "Translating the documentation" in *Contributor's Guide*, and Section "Translating the website" in *Contributor's Guide*.
- Bugfixes or new features: read Section "Programming work" in *Contributor's Guide*.

1.2 Overview of work flow

> **Advanced note:** Experienced developers should skip to Section 1.3 [Summary for experienced developers], page 2.

Git is a *version control system* that tracks the history of a program's source code. The LilyPond source code is maintained as a Git repository, which contains:

- all of the source files needed to build LilyPond, and
- a record of the entire history of every change made to every file since the program was born.

The 'official' LilyPond Git repository is hosted by the GNU Savannah software forge at `https://git.sv.gnu.org`. The server provides two separate interfaces for viewing the LilyPond Git repository online: cgit (`https://git.sv.gnu.org/cgit/lilypond.git/`) and gitweb (`https://git.sv.gnu.org/gitweb/?p=lilypond.git`).

However, the main development takes place at `https://gitlab.com/lilypond/lilypond/`, which also hosts the project's issues. Automatic mirroring ensures that 'important' branches (such as `master` and `stable/*`) are up to date on the 'official' repository at GNU Savannah, so you can also base your development on a clone from there.

Compiling ('building') LilyPond allows developers to see how changes to the source code affect the program itself. Compiling is also needed to package the program for specific operating systems or distributions. LilyPond can be compiled from a local Git repository (for developers), or from a downloaded tarball (for packagers). Compiling LilyPond is a rather involved process, and most contributor tasks do not require it.

Contributors can contact the developers through the 'lilypond-devel' mailing list. The mailing list archive is located at `https://lists.gnu.org/archive/html/lilypond-devel/`. If you have a question for the developers, search the archives first to see if the issue has already been discussed. Otherwise, send an email to `lilypond-devel@gnu.org`. You can subscribe to the developers' mailing list here: `https://lists.gnu.org/mailman/listinfo/lilypond-devel`.

> **Note:** Contributors on Windows or macOS wishing to compile code or documentation are strongly advised to use our Debian LilyPond Developer Remix, as discussed in Chapter 2 [Quick start], page 5.

1.3 Summary for experienced developers

If you are already familiar with typical open-source tools, here's what you need to know:

- **'Official' source repository:** hosted by GNU Savannah

  `https://git.savannah.gnu.org/gitweb/?p=lilypond.git`
- **Development platform:** hosted by GitLab; also includes the issue tracker (see Chapter 8 [Issues], page 69)

  `https://gitlab.com/lilypond/lilypond/`
- **Environment variables:** needed by many maintenance scripts, and many instructions in this guide rely on them; see Section 13.2 [Environment variables], page 121.
- **Mailing lists:** given in Section "Contact" in *General Information*.
- **Git branches:**
  - `master`: always base your work on this branch, but **never push** directly to it.

  - `dev/foo`: feel free to push any new branches under `dev/` and use GitLab to create *Merge Requests* (MR), which eventually get merged into `master` after they have passed automatic testing (see below).

- **Regression tests:** also known as "regtests". A collection of around two thousand `.ly` files that are used to track LilyPond's engraving output between released stable and unstable versions as well as checked for all patches submitted for testing.

  If a patch introduces any unintentional changes to any of the regtests it is very likely it will be rejected (to be fixed) – if you expect any regression test changes, always make sure that they are explained clearly as part of the patch description when submitting for testing. For more information, see Chapter 9 [Regression tests], page 73.

- **Reviews:** after finishing work on a patch or branch you should do the following.

  1. Commit the changes and create a Merge Request. See Section 3.3.1 [Uploading a patch for review], page 14, for more information.
  2. A Merge Request is usually automatically tested within an hour of submission. Once it has passed the basic tests – `make check`, `make`, `make doc` – the tracker will be updated and the patch's status will change to `Patch::review` for other developers to examine.
  3. Every third day, the "Patch Meister" will examine all Merge Requests currently under review, looking for any comments by other developers. Depending on what has been posted, the patch will be either "moved on" to the next patch status (`Patch::countdown`), set back to `Patch::needs_work`, or if more discussion is needed, left at `Patch::review`. In all cases the Merge Request will be updated by the Patch Meister accordingly.
  4. Once another three days have passed, any patch that has been given `Patch::countdown` status will be changed to `Patch::push`, the Merge Request is updated, and the developer can now rebase and merge to the `master` branch (or ask one of the other developers to merge it for you).

     Advanced note: This process means that most patches will take about a week before finally being merged into `master`. With the limited resources for reviewing patches available and a history of unintended breakages in the `master` branch (from patches that have not had time to be reviewed properly), this is the best compromise we have found.

1.4 Mentors

We have a semi-formal system of mentorship, similar to the medieval "journeyman/master" training system. New contributors will have a dedicated mentor to help them "learn the ropes".

> **Note:** This is subject to the availability of mentors; certain jobs have more potential mentors than others.

Contributor responsibilities

1. Ask your mentor which sections of the CG you should read.
2. If you get stuck for longer than ten minutes, ask your mentor. They might not be able to help you with all problems, but we find that new contributors often get stuck with something that could be solved or explained with two or three sentences from a mentor.
3. If you have been working on a task much longer than was originally estimated, stop and ask your mentor. There may have been a miscommunication, or there may be some time-saving tips that could vastly simplify your task.
4. Send patches to your mentor for initial comments.

5. Inform your mentor if you're going to be away for a month, or if you leave entirely. Contributing to LilyPond isn't for everybody; just let your mentor know so that we can reassign that work to somebody else.
6. Inform your mentor if you're willing to do more work – we always have way more work than we have helpers available. We try to avoid overwhelming new contributors, so you'll be given less work than we think you can handle.

Mentor responsibilities

1. Respond to questions from your contributor(s) promptly, even if the response is just "sorry, I don't know" or "sorry, I'm very busy for the next 3 days; I'll get back to you then". Make sure they feel valued.
2. Inform your contributor(s) about the expected turnaround for your emails – do you work on LilyPond every day, or every weekend, or what? Also, if you'll be unavailable for longer than usual (say, if you normally reply within 24 hours, but you'll be at a conference for a week), let your contributors know. Again, make sure they feel valued, and that your silence (if they ask a question during that period) isn't their fault.
3. Inform your contributor(s) if they need to do anything unusual for the builds, such as doing a `make clean` or `make doc-clean`, or switching git branches (not expected, but just in case).
4. You don't need to be able to completely approve patches. Make sure the patch meets whatever you know of the guidelines (documentation style, code indentation, whatever).
5. Keep track of patches from your contributor. Either open Merge Requests by yourself or help and encourage them to upload the patches themselves.
6. Encourage your contributor to review patches, particularly your own! It doesn't matter if they're not familiar with C++, Scheme, the build system, or the documentation guidelines – simply going through the process is valuable. Besides, anybody can find a typo!
7. Contact your contributor at least once a week. The goal is just to get a conversation started – there's nothing wrong with simply copying & pasting this into an email:

```
Hey there,

How are things going?  If you sent a patch and got a review, do
you know what you need to fix?  If you sent a patch but have no
reviews yet, do you know when you will get reviews?  If you are
working on a patch, what step(s) are you working on?
```

2 Quick start

Want to submit a patch for LilyPond? Great! Never created a patch before? Never compiled software before? No problem! This chapter is for you and will help you do this as quickly and easily as possible.

2.1 LilyDev

> **Note:** The following sections are based on LilyDev v2 and are not necessarily correct for different releases.

"LilyDev" is a custom GNU/Linux operating system which includes all the necessary software and tools to compile LilyPond, the documentation and the website (also see Chapter 6 [Website work], page 62).

While compiling LilyPond on macOS and Windows is possible, both environments are complex to set up. LilyDev can be easily run inside a 'virtual machine' on either of these operating systems relatively easily using readily available virtualization software. We recommend using VirtualBox as it is available for all major operating systems and is very easy to install & configure.

LilyDev comes in two 'flavours': containers and a standard disk image. Windows or macOS users should choose the Debian disk image (to be run in a virtual machine), that is the file named `LilyDev-VERSION-debian-vm.zip`. GNU/Linux users are recommended to choose one of the containers (currently Debian or Fedora), which are smaller in size, lightweight and easier to manage. The Fedora disk image has currently not been released, you can create it from the sources located in the `/mkosi` subdirectory of the LilyDev repository, however.

Download the appropriate file from here:

`https://github.com/fedelibre/LilyDev/releases/latest`

> **Note:** Apart from installing and configuring LilyDev in VirtualBox, the rest of the chapter assumes that you are comfortable using the command line and is intended for users who may have never created a patch or compiled software before. More experienced developers (who prefer to use their own development environment) may still find it instructive to skim over the following information.

If you are not familiar with GNU/Linux, it may be beneficial to read a few "introduction to Linux" type web pages.

Installing LilyDev in VirtualBox

This section discusses how to install and use LilyDev with VirtualBox.

> **Note:** If you already know how to install a virtual machine using a disc image inside VirtualBox (or your own virtualization software) then you can skip this section.

1. Download VirtualBox from here:

   `https://www.virtualbox.org/wiki/Downloads`

> **Note:** In virtualization terminology, the operating system where VirtualBox is installed is known as the **host**. LilyDev will be installed 'inside' VirtualBox as a **guest**.

2. The zip archive you downloaded contains the raw disk image and its SHA256 checksum. You can verify the integrity of the downloaded archive with any hashing tool your OS does support. On Linux, run the following command in the directory where you have extracted the files (this may take some time):

   ```
   sha256sum -c SHA256SUMS
   ```

   For Windows, look for the tools `FCIV` or `certutil` to compute the archive's hash.

3. As VirtualBox does not support the raw format, you have to extract it and then convert it to VDI format. Make sure that 'VBoxManage' is in your `PATH` or call it from your VirtualBox installation directory:

   ```
   VBoxManage convertfromraw LilyDev-VERSION-debian-vm.img \
     LilyDev-VERSION-debian-vm.vdi
   ```

   > **Note:** You need a fair amount of disk space (around 30 GB) to extract the raw image. After converting to a dynamic VirtualBox image it will take up much less space (only the amount of space that is actually allocated by the guest filesystem)

4. Start the VirtualBox software and click 'New' to create a new "virtual machine".

   The 'New Virtual Machine Wizard' walks you through setting up your guest virtual machine. Choose an appropriate name for your LilyDev installation and select the 'Linux' operating system. When selecting the 'version' choose 'Debian (64-bit)'. If you do not have that specific option choose 'Linux 2.6/3.x/4.x (64-bit)'.

5. Select the amount of RAM you allow the LilyDev guest to use from your host operating system when it is running. If possible, use at least 1 GB of RAM; the more RAM you can spare from your host the better

6. In the 'Hard Disk' step, you use the VDI file you have previously created. You may move it within the virtual machine's folder already created by the wizard (in GNU/Linux the default should be `~/VirtualBox VMs/NAME`). Click on 'Use an existing virtual hard disk file' and browse to the VDI file.

7. Verify the summary details and click 'Create' as soon as you are satisfied. Your new guest shall be displayed in the VirtualBox window now.

8. Enable EFI within the virtual machine's settings – click on System → Motherboard and select 'Extended features: Enable EFI'. Otherwise, you won't be able to boot the image.

9. VirtualBox 'guest additions', which are installed by default in the debian image, provide some additional features such as being able to dynamically resize the LilyDev window, allow seamless interaction with your mouse pointer on both the host and guest, and let you copy/paste between your host and guest if needed. It seems that dynamic window resizing works only with the 'VBoxVGA' graphics controller, which you can choose in Display → Graphics Controller. To enable clipboard sharing between guest and host, choose General → Advanced → Shared Clipboard → Bidirectional.

10. Click the 'Start' button and wait until the login screen appears. Log in as `dev` user then; type the password `lilypond`. Before starting any work, be sure to complete the next steps.

> **Note:** Since the default keyboard layout is US (American), you may have to type the password differently if you are using another layout, like 'lilzpond' on a German keyboard, for example.

11. Open a terminal by clicking Applications → Terminal at the upper left of the screen. You may want to change the password of user 'dev' before doing further work with the command `passwd`.
12. You might need to change the keyboard layout from default US (American) to your national layout. Therefore open a terminal and run

    ```
    sudo dpkg-reconfigure keyboard-configuration
    ```

    > **Note:** You need superuser rights to change certain aspects of the system configuration. The `sudo` tool allows to gain superuser rights temporarily. It does show you a warning message on its first use that reminds you to use your extended rights carefully.

    At first, you are prompted for the model of your keyboard. Press Enter to show further models. In most cases, it is sufficient to choose 'Generic, 105 keys'. After that, choose your keyboard layout. Now, you can customize the function of your `AltGr` key. Normally, the default layout settings fit well, so take number 1. The same holds for the question of whether you want to configure a 'compose' key. At last, you are asked if you want to configure `Ctrl+Alt+Backspace` as a shortcut to terminate the X server. Presumably, you do not need this, so you can safely type 'no'.
13. To set up your system language (charset, localized messages etc.), continue with

    ```
    sudo dpkg-reconfigure locales
    ```

    > **Note:** Restarting is required in order to take the changes into effect.

14. Finally, you should run a setup script. If you are on the command line already, simply type `./setup.sh` to run the interactive script that does set up git and downloads all the repositories needed to build LilyPond.

Configuring LilyDev in VirtualBox

- In the settings for the virtual machine, set the network to Bridged mode to allow you to access shared folders when using Windows hosts.
- Set up any additional features, such as 'Shared Folders' between your main operating system and LilyDev. This is distinct from the networked share folders in Windows. Consult the external documentation for this.

  Some longtime contributors have reported that 'shared folders' are rarely useful and not worth the fuss, particularly since files can be shared over a network instead.
- Pasting into a terminal is done with `Ctrl+Shift+v`.
- Right-click allows you to edit a file with the text editor (default is Leafpad).

Known issues and warnings

Not all hardware is supported in all virtualization tools. In particular, some contributors have reported problems with USB network adapters. If you have problems with network connection

(for example Internet connection in the host system is lost when you launch virtual system), try installing and running LilyDev with your computer's built-in network adapter used to connect to the network. Refer to the help documentation that comes with your virtualization software.

2.2 Compiling with LilyDev

LilyDev is our custom GNU/Linux which contains all the necessary dependencies to do LilyPond development; for more information, see Section 2.1 [LilyDev], page 5.

Preparing the build

To prepare the build directory, enter (or copy&paste) the below text. This should take less than a minute.

```
cd $LILYPOND_GIT
sh autogen.sh --noconfigure
mkdir -p build/
cd build/
../configure
```

Building `lilypond`

Compiling LilyPond will take anywhere between 1 and 15 minutes on most 'modern' computers – depending on CPU and available RAM. We also recommend that you minimize the terminal window while it is building; this can help speed up on compilation times.

```
cd $LILYPOND_GIT/build/
make
```

It is possible to run `make` with the `-j` option to help speed up compilation times even more. See Section 4.5 [Compiling LilyPond], page 28,

You may run the compiled `lilypond` with:

```
cd $LILYPOND_GIT/build/
out/bin/lilypond my-file.ly
```

Building the documentation

Compiling the documentation is a much more involved process, and will likely take 2 to 10 hours.

```
cd $LILYPOND_GIT/build/
make
make doc
```

The documentation is put in `out-www/offline-root/`. You may view the html files by entering the below text; we recommend that you bookmark the resulting page:

```
firefox $LILYPOND_GIT/build/out-www/offline-root/index.html
```

Installing

Don't. There is no reason to install LilyPond within LilyDev. All development work can (and should) stay within the `$LILYPOND_GIT` directory, and any personal composition or typesetting work should be done with an official release.

Problems and other options

To select different build options, or isolate certain parts of the build, or to use multiple CPUs while building, read Chapter 4 [Compiling], page 20.

In particular, contributors working on the documentation should be aware of some bugs in the build system, and should read the workarounds in Section 4.6.2 [Generating documentation], page 29.

2.3 Now start work!

LilyDev users may now skip to the chapter which is aimed at their intended contributions:

- Chapter 5 [Documentation work], page 35,
- Section 5.9 [Translating the documentation], page 53,
- Chapter 6 [Website work], page 62,
- Chapter 9 [Regression tests], page 73,
- Chapter 10 [Programming work], page 77,

These chapters are mainly intended for people not using LilyDev, but they contain extra information about the "behind-the-scenes" activities. We recommend that you read these at your leisure, a few weeks after beginning work with LilyDev.

- Chapter 3 [Working with source code], page 10,
- Chapter 4 [Compiling], page 20,

3 Working with source code

The LilyPond project uses Git (`https://git-scm.com/`) as a version control system. This section is intended at getting new contributors started with Git, and helping senior developers with less frequently used procedures.

3.1 Setting up

3.1.1 Installing Git

On UNIX systems (such as GNU/Linux, macOS, FreeBSD), the easiest way to download and install Git is through a package manager. Alternatively, you can visit the Git website (`https://git-scm.com/`) for downloadable installers.

For convenience, you may also install a graphical front-end to Git. Packaged in the installers come `gitk` (for browsing the history) and `git-gui` (for committing). Git's official website provides a list of GUI clients (`https://git-scm.com/downloads/guis/`), including free software for various platforms.

3.1.2 Creating a GitLab account and setting up SSH

First of all, since the patch review happens on GitLab, you need to create an account there if you do not already have one. Visit `https://gitlab.com` and register.

Second, you have to configure SSH keys for your GitLab account. The GitLab documentation has a dedicated page (`https://docs.gitlab.com/ee/user/ssh.html`) explaining the full steps. (Although this initial setup may look a little tedious, it ensures that you will not need to log in with your GitLab credentials every time you need to create or modify a merge request.)

Note that on the first Git operation you perform that involves connecting with GitLab (namely `git clone` if you follow the rest of this section in order), SSH will issue the following warning:

```
The authenticity of host 'gitlab.com' can't be established.
ECDSA key fingerprint is SHA256:HbW3g8zUjNSksFbqTiUWPWg2Bq1x8xdGUrliXFzSnUw.
Are you sure you want to continue connecting (yes/no/[fingerprint])?
```

When you see this, make sure the key fingerprint displayed matches the one above or one of the others published by GitLab (`https://docs.gitlab.com/ee/user/gitlab_com/index.html#ssh-host-keys-fingerprints`). If it doesn't, respond "no" and check that you configured Git properly in the previous step. If it does match, respond "yes". SSH should then issue another warning:

```
Warning: Permanently added 'gitlab.com' (ECDSA) to the list of known hosts.
```

The list of known hosts is stored in the file `~/.ssh/known_hosts`.

You might see error messages like these:

```
Permission denied (publickey).
fatal: The remote end hung up unexpectedly
```

If you get the above error, you may have made a mistake when registering your SSH key – for example, a common problem is to inadvertently add a final newline while copying and pasting the long key string. If the key is properly registered and it still doesn't work after an hour, ask for help on the mailing list.

If you would like to work on LilyPond from several machines, you may simply copy the `.ssh` folder contents from one to the other.

3.1.3 Cloning and forking the repository

Clone the LilyPond repository (`https://gitlab.com/lilypond/lilypond`) to get the source code and its history:

```
git clone git@gitlab.com:lilypond/lilypond.git
```

New contributors need to fork it in order to push branches. Using a fork is no longer necessary (but may be convenient) when you are given developer access. Visit `https://gitlab.com/lilypond/lilypond` and press "Fork" on the top right. After the fork is created, set up a new remote:

```
cd lilypond
git remote add fork git@gitlab.com:your-username/lilypond.git
```

To list remote repositories that are configured, along with their URLs:

```
git remote -v
```

You should have `origin` pointing to the official LilyPond repository, and `fork` pointing to your your private fork.

3.1.4 Configuring Git

Settings apply to any repository on your computer, unless you leave out the `--global` option.

You first need configure some basic settings required for keeping track of commit authors:

```
git config --global user.name "John Smith"
git config --global user.email john@example.com
```

It is also recommended to enable colored output:

```
git config --global color.ui auto
```

If none of your editor-related environment variables are set, the default text editor used for writing commit messages, etc., is usually `vim`. If your are not familiar with it, change it to an editor that you are comfortable with; for example, Gedit:

```
git config --global core.editor "gedit --wait --new-window"
```

Finally, and in some ways most importantly, let's make sure that we can easily see the state of our working copy. If you are not using LilyDev or Windows, add the following lines to your `~/.bashrc`:

```
export PS1="\u@\h \w\$(__git_ps1)$ "
export GIT_PS1_SHOWDIRTYSTATE=true
export GIT_PS1_SHOWUNTRACKEDFILES=true
export GIT_PS1_SHOWUPSTREAM=auto
```

After starting a new terminal, your prompt will show the current branch (this term and others are explained below). Additionally, some symbols next to the branch name indicate certain states. A star "*" means that there are unstaged changes. With a plus "+", the changes are staged. If there are untracked files, a percent "%" will appear. Finally, we can also see the state of the local repository compared to upstream: "=" means up to date, "<" is behind, ">" is ahead, "<>" means they have diverged.

You may need to install the additional `bash-completion` package.

3.2 Git cheat sheet

The intent of this section is to get you working on LilyPond quickly. If you want to learn about Git, see Section 3.6 [Further Git documentation resources], page 17.

Also, these instructions are designed to eliminate the most common problems we have found in using Git. If you already know Git and have a different way of working, great! Feel free to ignore this advice.

Pulling recent changes

As LilyPond's source code is continously improved, it is wise to integrate recent changes into your local copy whenever you start a working session. On the `master` branch (this term is explained below), run:

```
git pull
```

Viewing the history

Each change is contained in a *commit* with an explanatory message. To list commits starting from the latest:

```
git log
```

Press `Enter` to see more or `Q` to exit.

Start work: make a new branch

The Git workflow is based on branches, which can be viewed as different copies of the source code with concurrent changes that are eventually merged. You start a contribution by creating a branch, freezing the initial state of the source code you will base your work onto. Ultimately, your branch will be *merged* into `master`. This latter, special branch centralizes all features developed simultaneously and is the source for unstable releases.

> **Note:** Remember, **never** directly commit to `master`.

Let's pretend you want to add a section to the Contributor's Guide about using branches. To create a new branch for this:

```
git branch cg-add-branches
```

Switching branches

Switching branches is somehow like "loading a file", although in this case it is really "loading a directory and subdirectories full of files". The command to use is `git switch`.[1]

```
git switch master
git switch cg-add-branches
git switch origin/release/unstable
```

Branches that begin with `origin/` are part of the remote repository, rather than your local repository, so when you check them out you get a temporary local branch. Therefore, do not commit to these either. Always work in a local branch.

Listing branches

To list local branches:

```
git branch
```

If you want remote branches too:

```
git branch -a
```

In the output, the current branch is prefixed with a star.

Staging and committing files

Now edit files. To show a summary of your edits:

```
git status
```

For every file that you modified or added, first preview your changes:

```
git diff file
```

If everything looks right:

```
git add file
```

Then commit your changes:

```
git commit
```

A text editor window appears for you to write a commit message. See Section 3.4 [Writing good commit messages], page 16.

[1] If you are using an outdated version of Git (older than 2.23), you need to use `git checkout` instead.

Amending and reverting changes

To add some more changes to the latest commit, stage them using `git add`, then run:

```
git commit --amend
```

This also works for rephrasing the commit message.

You might want to use `git add -p` instead of `git add`; this allows you to add changes incrementally in an interactive way.

To revert changes to a file that have not been committed yet, use `git restore`:[2]

```
git restore filename
```

You might want to use `git reset -p` instead of `git restore`; this allows you to revert changes incrementally in an interactive way.

To get back to the last commit, *discarding all changes*:

```
git reset --hard HEAD
```

If the commit to edit is not the top one, you need to perform an *interactive rebase* with `git rebase -i $(git merge-base master HEAD)`. The full functionality of `git rebase -i` is not covered here; please try it and follow Git's instructions or read any tutorial on the Web.

Uploading your branch for review

To upload the current branch on the remote repository:

```
git push -u fork cg-add-branches
```

This sets the remote branch so subsequent pushes are simpler:

```
git push
```

The next section covers how to create a *Merge Request*[3] from your branch.

In response to review comments, you may need to amend your changes. Do *not* close your merge request and open a new one; instead, amend your commits, which can be done with `git commit --amend` or `git rebase -i` as explained above. Note that Git will by default refuse a push when you have amended your commits. This is because this kind of push is a destructive operation: once it is done, the old commits are no longer available on the remote branch. Git prevents this as a safety measure against deleting commits added by someone else without you realizing it. Do not follow Git's advice to do `git pull` (which would try to integrate the remote changes into the local ones); instead, just force it with

```
git push --force-with-lease
```

Also note that due to the way GitLab compares successive revisions of a merge request, it is preferable if you do not mix catching up with `master` and changing your commits. In other words, use `git rebase -i $(git merge-base master HEAD)` rather than `git rebase -i master`. Alternatively, first rebase on `master` and push, then do the interactive rebase and push again.

Deleting branches

After the merge request has passed testing and was merged to `master`, or after a failed experiment, you can delete your local branch.

```
git switch master
git branch -d cg-add-branches
```

As a safety measure, this will fail if the commits of `cg-add-branches` are not present in `master`. This can be because you used GitLab to rebase your branch, which modifies the commit

[2] If you are using an outdated version of Git (older than 2.23), you need to use `git checkout` instead.

[3] You may probably know this already under the name *Pull Request*, as it is called on the GitHub platform. It's not exactly the same, though.

data and changes the hash. If you are sure that the branch is not needed anymore, replace the `-d` on the final line with a `-D` instead.

Over time, remote branches of accepted merge requests may accumulate in your local repository. If you want to delete these and get back to the state of the official repository, run

```
git fetch -p origin
```

(short for `--prune`) once in a while.

3.3 Lifecycle of a merge request

3.3.1 Uploading a patch for review

- Any non-trivial change should be reviewed as a merge request:

  `https://gitlab.com/lilypond/lilypond/-/merge_requests`
- Ensure your branch differs from latest `master` by just the changes to be uploaded.
- Make sure that `make`, `make test`, and `make doc` succeed. Even if the individual commits contain incomplete features, they must **all** pass these tests.
- The names of branches pushed on the main repository should start with `dev/`.
- After pushing, create a merge request to start the review cycle. There are multiple options for this as outlined in GitLab's documentation (`https://docs.gitlab.com/ee/user/project/merge_requests/`). This will also ask you for a message that will accompany your patch.
- If you are not a member of the team and create the merge request from a fork, consider enabling the box to "Allow commits from members who can merge to the target branch". This makes it possible for somebody with permissions to rebase your changes and merge them for you. Please refer to Section 3.3.4 [Merging to master], page 15, for more details.

> **Note:** When commenting on GitLab, be careful if you talk about Texinfo markup. An '`@`' sign starts a reference to a person or a group. If you leave it without special markup, '`@foo`' makes the person who has `foo` as a GitLab username receive unsolicited notifications. To avoid this, enclose the markup in backticks: `` `@lilypond` ``. For code suggestions, there is also a dedicated feature, see the GitLab documentation (`https://docs.gitlab.com/ee/user/project/merge_requests/reviews/suggestions.html`) for information.

3.3.2 Automated testing

When a merge request is opened, a bot automatically adds the `Patch::new` label to it, and it enters the countdown cycle. GitLab triggers automated testing, which ensures that the patch completes `make`, `make check`, and `make doc`.

After the CI pipeline has succeeded, the patch meister or any developer (even the author) should check the regression test comparison. When there are no differences, the "Test summary" section of the merge request page has a green check mark. If it instead has a yellow exclamation mark, click the caret to expand the section, then click the "View details" link next to the "Machine review" entry. A window pops up with a link to the regression test visual comparison page.

If tests display no obviously bad differences, the patch can be advanced to `Patch::review`. If the size of the regression test visual differences allows it, please paste screenshots of them on the merge request page for easier review. Otherwise, simply paste a link to the that page.

Also, for changes that are by nature not expected to yield regression test differences, such as documentation improvements, it is not necessary to leave a comment at all. In case any of the testing steps fails, the patch should be set to `Patch::needs_work`. When revisions are made, this process repeats (if the regression test diff is not changed by the latest iteration, a comment stating so can replace posting screenshots again).

3.3.3 Patch countdown

The *Patch Meister* is the person who advances patches in the countdown process based on review comments.

> **Note:** The Patch Meister's role is a purely administrative one and no programming skill or judgement is assumed or required.

The current Patch Meister is Colin Campbell (`cpkc.music@shaw.ca`).

The Patch Meister reviews the tracker periodically, to list patches which have been on review for at least 24 hours. For each patch, the Patch Meister reviews any discussion on the merge request, to determine whether the patch can go forward. If there is any indication that a developer thinks the patch is not ready, the Patch Meister marks it with `Patch::needs_work` and makes a comment regarding the reason, referring to the comment if needed.

Patches with explicit approval, or at least no negative comment, are updated to `Patch::countdown`. The countdown is a 48-hour waiting period in which any final reviews or complaints should be made.

The Patch Meister sends an email to the developer list. The subject line has a fixed formatting, to enable filtering by email clients, like so:

```
PATCHES: Countdown for February 30th
```

The text of the email sets the deadline for this countdown batch. At present, batches are done on Tuesday, Thursday and Sunday evenings.

At the next countdown, if no problems were found, the patch will be set to `Patch::push`. New contributors should ask for it to be merged. Developers merge their patches themselves, see Section 3.3.4 [Merging to master], page 15, and Section 3.5 [Commit access], page 17.

Alternately, your patch may be set to `Patch::needs_work`, indicating that you should fix something (or at least discuss why the patch needs no modification). It also happens that patches waiting for minor fixes are put on countdown a second time.

Successive revisions made in response to comments are uploaded by pushing to the same branch. GitLab automatically keeps track of all pushed commits and allows to compare revisions with each other.

As in most organisations of unpaid volunteers, fixed procedures are useful in as much as they get the job done. In our community, there is room for senior developers to bypass normal patch handling flows, particularly now that the testing of patches is largely automated. Similarly, the minimum age of 24 hours can reasonably be waived if the patch is minor and from an experienced developer.

3.3.4 Merging to master

Before allowing a merge request to be merged, GitLab ensures the following:

1. The merge must be of type 'fast-forward'. In most cases, this can be achieved by 'rebasing' the branch with the most recent commits from `master`. GitLab provides a convenient button for that if no conflicts arise. Otherwise, or if preferred, the operation can be (or has to be) performed locally.

Please don't combine a rebase operation with changes of the merge request! Do it in two steps instead (usually first committing changes to the merge request, then rebasing). This makes it easier to review the changes.

2. The (possibly rebased) changes must have passed automatic testing. This ensures that the `master` branch is always clean and ready for development and translation.

After rebasing, GitLab will immediately start the automatic testing pipeline. At the moment, all steps may take up to one hour to complete. If you are confident about the rebased result of your changes, you may click "Merge when pipeline succeeds" to avoid waiting for the tests. On failure, the merge will be aborted and no harm is done to the `master` branch.

Because GitLab enforces fast-forward merges, this means only one set of changes can be rebased and merged at once. A second merge request would be rejected later on because it does not contain the commit(s) merged first. To avoid wasting testing resources, please prevent this situation by checking first whether a pipeline with a scheduled merge is already running. View the list of merge requests (`https://gitlab.com/lilypond/lilypond/-/merge_requests`) and verify that no merge request with `Patch::push` status has a blue "timer" icon.

How to merge a branch without rebasing

It is generally recommended to rebase commits before merging to get a linear history. However, this is not always possible or wanted. This particularly holds for translations and the `release/unstable` branch, which cannot be force-pushed. For these cases, use the following procedure:

1. Merge the branch manually using the command line. The example merges the `dev/translation` branch, assuming no pending changes in the local `master` branch:

```
git switch master
git pull
git merge dev/translation
git push origin HEAD:dev/translation
```

2. Open a merge request at GitLab. This will immediately trigger automatic testing as described above.
3. Accept the merge request once the testing finishes, or use the button to "Merge when pipeline succeeds".

3.3.5 Abandoned patches

Roughly at six month intervals, the Patch Meister can list the patches which have been set to `Patch::needs_work` and send the results to the developer list for review. In most cases, these patches should be marked `Patch::abandoned` but this should come from the developer if possible.

3.4 Writing good commit messages

Your commit message should begin with a one-line summary describing the change (no more than 50 characters long), and if necessary a blank line followed by more explanatory text (wrapped at 72 characters). Here is how a good commit message looks like:

```
Doc: add Baerenreiter and Henle solo cello suites

Added comparison of solo cello suite engravings to new essay with
high-resolution images.  Fixed cropping on Finale example.

Closes #1234.
```

The "Closes" part is specially recognized by GitLab. See the documentation for closing issues automatically (https://docs.gitlab.com/ee/user/project/issues/managing_issues.html#closing-issues-automatically).

Commit messages often start with a short prefix describing the general location of the changes. Commits affecting the documentation in English (or in several languages simultaneously) should be prefixed with "Doc:". When the commit affects only one of the translations, use "Doc-**:", where ** is the two-letter language code. For the website, this is "Web:" or "Web-**". Commits that change CSS files should use "Web: CSS" or "Doc: CSS:". Finally, changes to a single file are often prefixed with the name of the file involved.

The imperative form, e.g. "Include this in that", is strongly preferred over the descriptive form "That is now included in this".

See also this blog post (https://chris.beams.io/posts/git-commit/) for details on how to write good commit messages.

3.5 Commit access

New contributors are not able to push branches directly to the main repository – only members of the LilyPond development team have *commit access*. If you are a contributor and are interested in joining the development team, contact the Project Manager through the mailing list (lilypond-devel@gnu.org). Generally, only contributors who have already provided a number of patches which have been merged to the main repository will be considered for membership.

If you have been approved by the Project Manager, navigate to https://gitlab.com/lilypond and 'Request access' to the group. Make sure that your account can be related to your activity on the mailing list. If in doubt, please post the user name after requesting access.

Note that you will not have commit access until the Project Manager activates your membership. Once your membership is activated, LilyPond should appear under the heading "Groups" on your profile page. When this is done, you can test your commit access with a dry run:

```
git push --dry-run --verbose
```

3.6 Further Git documentation resources

The following page on the Git website provides links to the Pro Git book and a variety of tutorials, as well as the official man pages (also available with `man git ...`).

```
https://git-scm.com/doc
```

The GitLab user documentation contains tutorials on using Git and GitLab:

```
https://docs.gitlab.com/ee/tutorials/#use-git
```

3.7 Repository directory structure

The following is a verbatim output of the file ROADMAP, which can be found in the top-level directory of LilyPond's git repository.

```
Prebuilt Documentation and packages are available from:

    http://www.lilypond.org

LilyPond development is hosted at:

    https://gitlab.com/lilypond/

Here is a simple explanation of the directory layout for
LilyPond's source files.
```

```
.                       Toplevel README's, files for
|                         configuration and building, etc.
|
|-- Documentation/      Top sources for most of the manuals
|   |
|   |
|   |   INDIVIDUAL CHAPTERS FOR EACH MANUAL:
|   |     Note: "Snippets" and "Internals Reference" are
|   |     auto-generated during the Documentation Build process.
|   |
|   |
|   |-- en/contributor/  Contributor's Guide
|   |-- en/essay/        Essay on automated music engraving
|   |-- en/extending/    Extending the functionality of LilyPond
|   |-- en/included/     Doc files that are used more than once
|   |-- en/learning/     Learning Manual
|   |-- en/notation/     Notation Reference
|   |-- en/usage/        How to run the programs that come with LilyPond
|   |-- en/web/          Website files
|   |
|   |
|   |   TRANSLATED MANUALS:
|   |     Each language's directory can contain...
|   |       1) translated versions of:
|   |          * "en/*" sources for manuals
|   |          * individual chapters for each manual
|   |       2) a texidocs/ directory for snippet translations
|   |
|   |-- ca/              Catalan
|   |-- de/              German
|   |-- es/              Spanish
|   |-- fr/              French
|   |-- it/              Italian
|   |-- ja/              Japanese
|   |-- tr/              Turkish
|   |-- zh/              Chinese
|   |
|   |
|   |   MISCELLANEOUS DOC STUFF:
|   |
|   |-- bib/             Bibliography files for documentation
|   |-- css/             CSS files for HTML docs
|   |-- logo/            Web logo and "note" icon
|   |-- ly-examples/     `.ly` example files for the webpage
|   |-- misc/            Old announcements, ChangeLogs and NEWS
|   |-- pictures/        Images (eps/jpg/png/svg) for the webpage
|   |   `-- pdf/         (pdf)
|   |-- po/              Translations for build/maintenance scripts
|   |-- snippets/        Auto-generated from the LSR and from ./new/
|   |   `-- new/         Snippets too new for the LSR
|   |-- tex/             TeX and texinfo library files
|   |-- topdocs/         AUTHORS, INSTALL
|   `-- webserver        Support files for the lilypond.org web server
|
|
|   C++ SOURCES:
|
|-- flower/              A simple C++ library
|   `-- include/         C++ header files for basic LilyPond structures
|-- lily/                C++ sources for the LilyPond binary
|   `-- include/         C++ header files for higher-level stuff
|
|
|   LIBRARIES:
|
```

```
|-- ly/                 `.ly` \include files
|-- mf/                 MetaFont sources and scripts for Emmentaler fonts
|-- ps/                 PostScript library files
|-- scm/                Scheme sources for LilyPond and subroutine files
|
|
|   SCRIPTS:
|
|-- config/             Autoconf helpers for configure script
|-- m4/                 Files used while generating the configure script
|-- python/             Python modules, MIDI module
|   `-- auxiliar/       Python modules for build/maintenance
|       `-- vendored/   External Python packages used during build
|-- scripts/            End-user scripts (--> lilypond/usr/bin/)
|   |-- auxiliar/       Maintenance and non-essential build scripts
|   `-- build/          Essential build scripts
|
|
|   BUILD PROCESS:
|   (also see SCRIPTS section above)
|
|-- make/               Specific make subroutine files
|
|-- docker/
|   |-- base/           CI Docker files used for running `make`
|   |-- ci/             Support for continuous integration (CI) on gitlab
|   `-- doc/            CI Docker files used for running `make doc`
|
|-- release/            Scripts to generate and upload release packages
|   |-- binaries/       Scripts to build binaries
|   |   |-- ansible/    Ansible playbooks for building binaries
|   |   |-- lib/        Auxiliary files for building binaries
|   |   |-- patches/    Patch files for external programs
|   |   `-- relocate/   Relocation data for lilypond binary
|   `-- doc             Scripts to build documentation
|
|
|   REGRESSION TESTS:
|
|-- input/
|   `-- regression/     `.ly` regression tests
|       |-- abc2ly/     `.abc` regression tests
|       |-- include-path-modification/
|       |               Regression test directory for include paths
|       |-- lilypond-book/
|       |               `lilypond-book` regression tests
|       |-- midi/       `midi2ly` regression tests
|       |-- musicxml/   MusicXML regression tests (for `musicxml2ly`)
|       `-- other/      Regression tests without graphical output
|
|
|   MISCELLANEOUS:
|
|-- elisp/              Emacs LilyPond mode and syntax coloring
|-- vim/                Vi(M) LilyPond mode and syntax coloring
`-- po/                 Translations for binaries and end-user scripts
```

4 Compiling

This chapter describes the process of compiling the LilyPond program from source files.

4.1 Overview of compiling

Compiling LilyPond from source is an involved process, and is only recommended for developers and packagers. Typical program users are instead encouraged to obtain the program from a package manager (on Unix) or by downloading a precompiled binary configured for a specific operating system. Pre-compiled binaries are available on the Section "Download" in *General Information* page.

Compiling LilyPond from source is necessary if you want to build, install, or test your own version of the program.

A successful compile can also be used to generate and install the documentation, incorporating any changes you may have made. However, a successful compile is not a requirement for generating the documentation. The documentation can be built using a Git repository in conjunction with a locally installed copy of the program. For more information, see [Building documentation without compiling], page 31.

Attempts to compile LilyPond natively on Windows have been unsuccessful, though a workaround is available (see Section "LilyDev" in *Contributor's Guide*).

4.2 Requirements

4.2.1 Requirements for running LilyPond

This section contains the list of software packages that are required to run LilyPond (this is, to successfully execute the `lilypond` binary and its subprograms to output a PDF, and to execute other programs like `lilypond-book` that are installed, too).

Additional software packages are necessary to compile LilyPond from its sources; this gets handled in a later section.

- Cairo (`https://www.cairographics.org`)
  Use version 1.16 or newer.
- FontConfig (`https://www.fontconfig.org`)
  Use at least version 2.13; however, we recommend version 2.15 or newer so that LilyPond can better reject Font Variations (see Section "Unsupported font formats" in *Notation Reference* and [this warning], page 25).
- FreeType (`https://www.freetype.org`)
  Use version 2.10 or newer.
- Ghostscript (`https://www.ghostscript.com`)
  Use version 9.03 or newer.
- GLib (`https://gitlab.gnome.org/GNOME/glib/`) (also required for Pango)
  Use version 2.64 or newer. Please note that LilyPond requires `GRegex` support in GLib. In turn, this implies that PCRE, the library GLib utilizes for regular expressions, must be built with Unicode support. In PCRE1, the flags `--enable-utf --enable-unicode-properties` must have been passed to the `configure` script when compiling PCRE; this is the case in most GNU/Linux distributions. In PCRE2, Unicode support is enabled by default.
- Guile (`https://www.gnu.org/software/guile/guile.html`)
  Use version 3.0.7 or later point releases.
- libpng (`http://www.libpng.org/pub/png/libpng.html`)
  Use version 1.6 or newer.

- Pango (`https://www.pango.org`)
  Use version 1.44.5 or newer.
- Python (`https://www.python.org`)
  Use version 3.10 or newer.
- Text fonts
  By default, LilyPond uses the families C059, Nimbus Mono PS, and Nimbus Sans of the URW++ package.

  Some distributions do not provide these fonts' OTF files. If they are missing, download and manually extract the OTF files to your local `~/.fonts/` directory.

  Some languages, such as Vietnamese, do not have glyphs in the URW++ fonts. When a glyph is not found in those fonts, LilyPond attempts to fall back to the families Cursor, Heros, and Schola of the TeX Gyre package. Note for downstream packagers: while packaging the URW++ fonts is important in order to make (most) LilyPond files render the same across environments, packaging the TeX Gyre fonts is optional; you can make them an optional dependency, for example.

  For more details on text fonts, please see Section "Fonts" in *Notation Reference*.

4.2.2 Requirements for compiling LilyPond

This section contains instructions on how to quickly and easily get all the software packages required to build LilyPond.

Most of the more popular Linux distributions only require a few simple commands to download all the software needed. For others, there is an explicit list of all the individual packages (as well as where to get them from) for those that are not already included in your distributions' own repositories.

Additional software packages are necessary to compile LilyPond's documentation from its sources; this gets handled in a later section.

Fedora

The following instructions were tested on 'Fedora' versions 22 & 23 and will download all the software required to both compile LilyPond and build the documentation.

- Download and install all the LilyPond build-dependencies (approximately 700MB);

  ```
  sudo dnf builddep lilypond --nogpgcheck
  ```

- Download and install additional 'build' tools required for compiling;

  ```
  sudo dnf install autoconf gcc-c++
  ```

- Although not 'required' to compile LilyPond, if you intend to contribute to LilyPond (codebase or help improve the documentation) then it is recommended that you also need to install `git`.

  ```
  sudo dnf install git
  ```

  Also see Section "Working with source code" in *Contributor's Guide*.

> **Note:** By default, when building LilyPond's documentation, pdfTeX is used. However, ligatures (fi, fl, ff, etc.) may not be printed in the PDF output. In this case XeTeX can be used instead. Download and install the `texlive-xetex` package.
>
> ```
> sudo dnf install texlive-xetex
> ```
>
> The scripts used to build the LilyPond documentation will use XeTeX instead of pdfTeX to generate the PDF documents if it is available. No additional configuration is required.

Linux Mint

The following instructions were tested on 'Linux Mint 17.1' and 'LMDE - Betsy' and will download all the software required to both compile LilyPond and build the documentation.

- Enable the *sources* repository;
  1. Using the *Software Sources* GUI (located under *Administration*).
  2. Select *Official Repositories*.
  3. Check the *Enable source code repositories* box under the *Source Code* section.
  4. Click the *Update the cache* button and when it has completed, close the *Software Sources* GUI.
- Download and install all the LilyPond build-dependencies (approximately 200MB);

  ```
  sudo apt-get build-dep lilypond
  ```
- Download and install additional 'build' tools required for compiling;

  ```
  sudo apt-get install autoconf fonts-texgyre texlive-lang-cyrillic
  ```
- Although not 'required' to compile LilyPond, if you intend to contribute to LilyPond (codebase or help improve the documentation) then it is recommended that you also need to install `git`.

  ```
  sudo apt-get install git
  ```

  Also see Section "Working with source code" in *Contributor's Guide*.

> **Note:** By default, when building LilyPond's documentation, pdfTEX is used. However, ligatures (fi, fl, ff, etc.) may not be printed in the PDF output. In this case XeTEX can be used instead. Download and install the `texlive-xetex` package.
>
> ```
> sudo apt-get install texlive-xetex
> ```
>
> The scripts used to build the LilyPond documentation will use XeTEX instead of pdfTEX to generate the PDF documents if it is available. No additional configuration is required.

OpenSUSE

The following instructions were tested on 'OpenSUSE 13.2' and will download all the software required to both compile LilyPond and build the documentation.

- Add the *sources* repository;

  ```
  sudo zypper addrepo -f \
  "http://download.opensuse.org/source/distribution/13.2/repo/oss/" sources
  ```
- Download and install all the LilyPond build-dependencies (approximately 680MB);

  ```
  sudo zypper source-install lilypond
  ```
- Download and install additional 'build' tools required for compiling;

  ```
  sudo zypper install make
  ```
- Although not 'required' to compile LilyPond, if you intend to contribute to LilyPond (codebase or help improve the documentation) then it is recommended that you also need to install `git`.

  ```
  sudo zypper install git
  ```

  Also see Section "Working with source code" in *Contributor's Guide*.

> **Note:** By default, when building LilyPond's documentation, pdfTEX is used. However, ligatures (fi, fl, ff, etc.) may not be printed in the PDF output. In this case XeTEX can be used instead. Download and install the `texlive-xetex` package.
>
> ```
> sudo zypper install texlive-xetex
> ```
>
> The scripts used to build the LilyPond documentation will use XeTEX instead of pdfTEX to generate the PDF documents if it is available. No additional configuration is required.

Ubuntu

The following commands were tested on Ubuntu versions `14.04 LTS`, `14.10` and `15.04` and will download all the software required to both compile LilyPond and build the documentation.

- Download and install all the LilyPond build-dependencies (approximately 200MB);

  ```
  sudo apt-get build-dep lilypond
  ```

- Download and install additional 'build' tools required for compiling;

  ```
  sudo apt-get install autoconf fonts-texgyre texlive-lang-cyrillic
  ```

- Although not 'required' to compile LilyPond, if you intend to contribute to LilyPond (codebase or help improve the documentation) then it is recommended that you also need to install `git`.

  ```
  sudo apt-get install git
  ```

  Also see Section "Working with source code" in *Contributor's Guide*.

> **Note:** By default, when building LilyPond's documentation, pdfTEX is used. However, ligatures (fi, fl, ff, etc.) may not be printed in the PDF output. In this case XeTEX can be used instead. Download and install the `texlive-xetex` package.
>
> ```
> sudo apt-get install texlive-xetex
> ```
>
> The scripts used to build the LilyPond documentation will use XeTEX instead of pdfTEX to generate the PDF documents if it is available. No additional configuration is required.

Other

The following software packages are required to compile LilyPond, in addition to the run-time packages (see Section 4.2.1 [Requirements for running LilyPond], page 20).

- GNU Autoconf (`https://www.gnu.org/software/autoconf`)
- pkg-config (`https://www.freedesktop.org/wiki/Software/pkg-config`)
- GNU Bison (`https://www.gnu.org/software/bison`)
  Use version 2.4.1 or newer.
- Compiler with support for C++17
  Version 8 or newer of the GNU Compiler Collection (`https://gcc.gnu.org`) and version 8 or newer of Clang (`https://clang.llvm.org`) should work. Your mileage may vary with older versions.
- Flex (`https://github.com/westes/flex`)
  Use version 2.5.29 or newer.

- FontForge (`https://fontforge.org`)
  Use version 20200314 or newer with enabled Python 3 scripting; it must also be compiled with the `--enable-double` switch, else this can lead to inaccurate intersection calculations, which in turn cause poorly-rendered glyphs in the output.
- GNU gettext (`https://www.gnu.org/software/gettext/gettext.html`)
  Use version 0.17 or newer.
- GNU Make (`https://www.gnu.org/software/make`)
  Use version 4.2 or newer.
- MetaFont (`http://metafont.tutorial.free.fr`)
  The MetaFont binary (usually called `mf-nowin`, `mf`, `mfw`, or `mfont`) and its support files are normally packaged along with TEX. Most GNU/Linux and other free software distributions already provide packages for TEX Live (`https://tug.org/texlive`), see above. TEX Live can can also be installed separately; it contains stand-alone binaries for most platforms.
- MetaPost (`https://www.tug.org/metapost.html`)
  The `mpost` binary is also usually packaged with TEX (`https://tug.org/texlive`). Use version 2.0 or newer.
- Perl (`https://www.perl.org`)
  Use version 5.6.1 or newer.
- Texinfo (`https://www.gnu.org/software/texinfo`)
  Use version 6.8 or newer.
- Type 1 utilities (`https://www.lcdf.org/~eddietwo/type/#t1utils`)
  We need `t1asm`. Use version 1.33 or newer.

4.2.3 Requirements for building documentation

The entire set of documentation for the most current build of LilyPond is available online at `https://lilypond.org/doc/latest/Documentation/web/development`, but you can also build them locally from the source code. This process requires the following tools and packages, in addition to the build and run-time packages (see Section 4.2.2 [Requirements for compiling LilyPond], page 21, and Section 4.2.1 [Requirements for running LilyPond], page 20).

> **Note:** If the instructions for one of the GNU/Linux distributions listed earlier (see Section 4.2.2 [Requirements for compiling LilyPond], page 21) have been used, the following can be ignored, as the necessary software packages should already be installed.

- ImageMagick (`https://www.imagemagick.org`)
  We need the `convert` tool.
- gzip (`https://gzip.org`)
- rsync (`https://rsync.samba.org`)
- To get reproducible documentation builds (this is, PDF documentation files contain the same fonts regardless of the build platform), the following font families should be installed.

  URW++ and TeX Gyre, as described before

  Bitstream Vera Sans

  Bitstream Charter

  DejaVu Sans

  DejaVu Serif

  DejaVu Sans Mono

  Linux Libertine O

Noto Serif CJK JP/Noto Serif JP

It is recommended to install the standard Roman (or Regular), Italic, Bold, and Bold Italic styles for all listed families; for the large Japanese fonts of the 'Noto Serif CJK JP' or 'Noto Serif JP' family, Regular and Bold styles are sufficient.

> **Note:** Be careful to install a version of 'Noto Serif CJK JP' that works with LilyPond! For technical reasons, neither the CFF2 font format nor Font Variations (VF) are supported, and many GNU/Linux distributions use exactly that for the Noto CJK family as a fallback. While Font Variations are filtered out by LilyPond's `99-lilypond-fonts.conf` configuration file for FontConfig, this cannot be done for CFF2. If you encounter errors during `make doc` related to Noto Serif CJK, consider to download fitting fonts directly from their repository[1,2] and to install them into your local fonts directory (for example, `~/.fonts`) so that FontConfig finds them first.

- extractpdfmark (`https://github.com/trueroad/extractpdfmark`)
  This is an optional component. However, it is highly recommended due to the large number of included PDF snippets. While making the compilation process much slower, it helps reduce the PDF output size by large amounts: for example, the size of the Notation Reference shrinks from approx. 30 MB to 7 MB.
- Finally, to convert LilyPond's documentation (in Texinfo format) to PDF files, including more than a thousand PDF snippets generated by LilyPond, XeTeX (`https://tug.org/xetex/`) is used by default. If not available, pdfTeX (`https://tug.org/applications/pdftex/index.html`) is tried instead.

  Not surprisingly, both XeTeX and pdfTeX are also part of TeX Live. Most GNU/Linux and other free software distributions already provide packages for TeX Live (`https://tug.org/texlive`), see above. TeX Live can can also be installed separately; it contains stand-alone binaries for most platforms.

  To support syntax highlighting of LilyPond source code in the PDF manuals (using the 'pygments' Python package), typewriter shapes of the Computer Modern font family are replaced with the extended set of shapes provided by Latin Modern. For this reason, two more TeX Live packages are necessary in case they are not already installed: 'fontinst' (a macro package for plain TeX) and 'lmodern' (we need some `.pfb` and `.afm` files). Additionally, the utility program `pltotf` must be available.

4.3 Getting the source code

Downloading the Git repository

In general, developers compile LilyPond from within a local Git repository. Setting up a local Git repository is explained in Section "Setting up" in *Contributor's Guide*.

Downloading a source tarball

Packagers are encouraged to use source tarballs for compiling.

The tarball for the latest stable release is available on the Section "Source" in *General Information* page.

[1] `https://github.com/notofonts/noto-cjk/blob/main/Serif/OTF/Japanese/NotoSerifCJKjp-Regular.otf`

[2] `https://github.com/notofonts/noto-cjk/blob/main/Serif/OTF/Japanese/NotoSerifCJKjp-Bold.otf`

The latest source code snapshot (`http://git.savannah.gnu.org/gitweb/?p=lilypond.git;a=snapshot`) is also available as a tarball from the GNU Savannah Git server.

All tagged releases (including legacy stable versions and the most recent development release) are available here:

`https://lilypond.org/download/source/`

Download the tarball to your `~/src/` directory, or some other appropriate place.

> **Note:** Be careful where you unpack the tarball! Any subdirectories of the current folder named `lilypond-2.26.0/` are overwritten if there is a name clash with the tarball.

Unpack the tarball with this command:

```
tar -xzf lilypond-2.26.0.tar.gz
```

This creates a subdirectory within the current directory called `lilypond-2.26.0/`. Once unpacked, the source files occupy about 66 MB of disk space.

Windows users wanting to look at the source code may have to download and install the free-software 7zip archiver (`https://www.7-zip.org`) to extract the tarball.

4.4 Configuring `make`

4.4.1 Build modes

LilyPond supports two build modes to prepare the execution of the `make` command.

- 'In-tree' compilation. This is the classical build mode of projects that use a `configure` script. The main disadvantage, however, is cluttering the source directory with generated files. We thus don't recommend it except for special purposes[3] that we don't cover here.
- Compilation using a build directory. A common name and location is a directory called `build/` in the top-level source directory; the following instructions expect exactly that.

4.4.2 Running `autogen.sh`

(If you use a tarball, follow the instructions in this subsection but don't actually run the `autogen.sh` script – the tarball already comes with a `configure` script.)

After cloning the Git repository or downloading and unpacking a Git snapshot, the contents of your top source directory should be similar to the current source tree listed at `https://git.sv.gnu.org/gitweb/?p=lilypond.git;a=tree`.

Note that the top-level source directory is called `lilypond-2.26.0/` if you use the tarball. It is called `lilypond-HEAD-`*ID*`/` if you use a Git snapshot, with *ID* being a hexadecimal, seven-digit number (for example, `lilypond-HEAD-80113f7/`). It is simply called `lilypond/` if you directly use the Git clone, and we use this in the following instructions.

Start with changing to the source directory, creating a build directory, and changing into it.

```
cd lilypond/
mkdir build/
cd build/
```

Because there are no generated files in the repository, you have to generate the `configure` script first. There are two possibilities to do that.

- Generate the `configure` script in the top-level source directory. This is what the instructions below do.

[3] For example, translators are required to build LilyPond in-tree, otherwise the translation helper scripts won't work.

- Using `autogen.sh`'s `--currdir` option it is possible to generate the `configure` script in the build directory. We don't cover this slightly more complicated setup here.

(If you omit the `--noconfigure` option, `autogen.sh` not only creates the `configure` script but also executes it, forwarding all given command-line options. This is a convenient shorthand for experienced users. For clarity, however, we explain the process in two separate steps.)

Execute the `autogen.sh` script now.

```
../autogen.sh --noconfigure
```

4.4.3 Running `configure`

Configuration options

> **Note:** make sure that you are in the `build/` subdirectory of your source tree.

The `../configure` command (generated by `../autogen.sh`) provides many options for configuring `make`. To see them all, run

```
../configure --help
```

Checking build dependencies

> **Note:** make sure that you are in the `build/` subdirectory of your source tree.

When `../configure` is run without any arguments, it checks whether your system has everything required for compilation.

```
../configure
```

If any build dependency is missing, `../configure` returns with

```
ERROR: Please install required programs:  foo
```

The following message is issued if you are missing programs that are only needed for building the documentation.

```
WARNING: Please consider installing optional programs:  bar
```

If you intend to build the documentation locally, you need to install or update these programs accordingly.

> **Note:** `../configure` may fail to issue warnings for certain documentation build requirements that are not met. If you experience problems when building the documentation, you may need to do a manual check; see Section 4.2.3 [Requirements for building documentation], page 24.

Configuring target directories

> **Note:** make sure that you are in the `build/` subdirectory of your source tree.

If you intend to use your local build to install a local copy of the program, you probably want to configure the installation directory. Here are the relevant lines taken from the output of `../configure --help`:

By default, `make install` will install all the files in `/usr/local/bin`, `/usr/local/lib` etc. You can specify an installation prefix other than `/usr/local` using `--prefix`, for instance `--prefix=$HOME`.

A typical installation prefix is `$HOME/usr`.

```
../configure --prefix=$HOME/usr
```

Note that if you plan to install a local build on a system where you do not have root privileges, you need to do something like this anyway – `make install` only succeeds if the installation prefix points to a directory where you have write permission (such as your home directory). The installation directory is automatically created if necessary.

The location of the `lilypond` command installed by this process is *prefix*`/bin/lilypond`; you may want to add *prefix*`/bin/` to your `$PATH` if it is not already included.

It is also possible to specify separate installation directories for different types of program files. See the full output of `../configure --help` for more information.

See Section 4.7 [Problems], page 32, if you encounter any problems.

4.5 Compiling LilyPond

4.5.1 Using `make`

> **Note:** make sure that you are in the `build/` subdirectory of your source tree.

LilyPond is compiled with the `make` command. Assuming `make` is configured properly, you can simply run:

```
make
```

'`make`' is short for '`make all`'. To view a list of `make` targets, run:

```
make help
```

By default, `.scm` files are byte-compiled. If you don't want to do that for whatever reason, add `BYTECODE=no` as an argument to `make`.[4]

TODO: Describe what `make` actually does.

See also

Section 4.6.2 [Generating documentation], page 29, provides more info on the `make` targets used to build the LilyPond documentation.

4.5.2 Saving time with the `-j` option

If your system has multiple CPUs, you can speed up compilation by adding '`-j`*X*' to the `make` command, where '*X*' is one more than the number of cores you have. For example, a typical Core2Duo machine would use:

```
make -j3
```

If you get errors using the `-j` option, and '`make`' succeeds without it, try lowering the *X* value.

Because multiple jobs run in parallel when `-j` is used, it can be difficult to determine the source of an error when one occurs. In that case, running '`make`' without the `-j` is advised.

[4] Byte compilation of Scheme code is disabled while cross-compiling since Guile must bootstrap itself to do that, which is not possible in general.

4.5.3 Useful `make` variables

`make` normally echoes each command, but LilyPond makefiles suppress this behavior by default. The goal is to show progress without hiding warnings and errors in the noise of long commands.

To enable echoing commands, and to increase the verbosity of some of the commands, set `VERBOSE=1` on the command line or in `local.make` at the top of the build tree.

Similarly, to reduce the verbosity, set `SILENT=1`. Because of the way these options are implemented, `make -s` does not serve this purpose.

4.6 Post-compilation options

4.6.1 Installing LilyPond from a local build

If you configured `make` to install your local build in a directory where you normally have write permission (such as your home directory), and you have compiled LilyPond by running `make`, you can install the program in your target directory by running:

```
make install
```

If instead your installation directory is not one that you can normally write to (such as the default `/usr/local/`, which typically is only writeable by the superuser), you will need to temporarily become the superuser when running `make install`:

```
sudo make install
```

or...

```
su -c 'make install'
```

If you don't have superuser privileges, then you need to configure the installation directory to one that you can write to, and then re-install. See [Configuring target directories], page 27.

If you have added `BYTECODE=no` as an argument to `make all`, you should do the same for `make install`.

4.6.2 Generating documentation

Three levels of documentation are available for installation. The following table lists them in order of increasing complexity, along with the command sequence to install each.

Level	Images	Web	Command
Reduced Info	no	no	`make && make install`
Full Info	Yes	no	`make && make info && make install-info`
Web	yes	yes	`make && make doc && make install-doc`

The web documentation includes all info files, images, and web documents. The reduced info option omits images and info files that are either highly dependent upon images, or discuss technical program details.

Documentation editor's edit/compile cycle

To work on a manual, do the following

- Build lilypond itself

  ```
  make [-jX]
  ```

- Then build the specific manual to work on, and inspect:

  ```
  ## edit source files, then...
  make CPU_COUNT=X -C Documentation out=www out-www/LANGUAGE/MYMANUAL.pdf

  ## if you prefer checking HTML files
  make CPU_COUNT=X -C Documentation out=www out-www/LANGUAGE/MYMANUAL/index.html
  ```

- To remove compiled documentation from your system, use 'make doc-clean' in the toplevel build directory.

Building documentation

After a successful compile (using make), the documentation can be built by issuing:

```
make doc
```

or, to build only the PDF documentation and not the HTML version,

```
make -C Documentation out=www pdf
```

> **Note:** The first time you run make doc, the process can easily take a very long time with not much output on the command line.

After this initial build, make doc only makes changes to the documentation where needed, so it may only take a minute or two to test changes if the documentation is already built.

If make doc succeeds, the HTML documentation tree is available in out-www/offline-root/, and can be browsed locally. The documentation can also be inspected in the Documentation/out-www subdirectory.

make doc sends the output from most of the compilation to logfiles. If the build fails for any reason, it should print the name of a logfile, explaining what failed.

make doc compiles the documents for all languages. To save some compile time, the English language documents can be compiled on their own with:

```
make LANGS='en' doc
```

Similarly, it is possible to compile a subset of the translated documentation by specifying their language codes on the command line. For example, the French and German translations are compiled with:

```
make LANGS='de fr' doc
```

To get correct word hyphenation in the non-English PDF documentation files you should install proper TEX Live packages for your platform, for example, 'texlive-hyphen-german' or 'texlive-hyphen-french'. If you have enough disk space you might simply install 'texlive-full' instead to get everything in one rush.

Compilation of documentation in Info format with images can be done separately by issuing:

```
make info
```

An issue when switching branches between master and translation is the appearance/disappearance of translated versions of some manuals. If you see such a warning from make:

```
No rule to make target 'X', needed by 'Y'
```

Your best bet is to delete the file Y.dep and to try again.

Building a single document

It's possible to build a single document. For example, to rebuild only contributor.pdf, do the following:

```
cd build/
cd Documentation/
touch ../../Documentation/en/contributor.texi
make out=www out-www/en/contributor.pdf
```

If you are only working on a single document, test-building it in this way can give substantial time savings - recreating contributor.pdf, for example, takes a matter of seconds.

Saving time with CPU_COUNT

The most time consuming task for building the documentation is running LilyPond to build images of music, and there cannot be several simultaneously running `lilypond-book` instances, so the `-j make` option does not significantly speed up the build process. To help speed it up, the makefile variable `CPU_COUNT` may be set in `local.make` or on the command line to the number of `.ly` files that LilyPond should process simultaneously, e.g., on a dual core machine:

```
make -j2 CPU_COUNT=2 doc
```

The recommended value of `CPU_COUNT` is the number of cores. If the build runs into out-of-memory problems, use a lower number.

Installing documentation

The HTML, PDF and if available Info files can be installed into the standard documentation path by issuing

```
make install-doc
```

This also installs Info documentation with images. The final installation of Info documentation (integrating it into the documentation directory) is printed on standard output.

To install the Info documentation separately, run:

```
make install-info
```

Note that to get the images in Info documentation, `install-doc` target creates symbolic links to HTML and PDF installed documentation tree in *prefix*`/share/info`, in order to save disk space, whereas `install-info` copies images in *prefix*`/share/info` subdirectories.

It is possible to build a documentation tree in `out-www/online-root/`, with special processing, so it can be used on a website with content negotiation for automatic language selection; this can be achieved by issuing

```
make WEB_TARGETS=online doc
```

and both ‘offline’ and ‘online’ targets can be generated by issuing

```
make WEB_TARGETS="offline online" doc
```

Several targets are available to clean the documentation build and help with maintaining documentation; an overview of these targets is available with

```
make help
```

from every directory in the build tree. Most targets for documentation maintenance are available from `Documentation/`; for more information, see Section “Documentation work” in *Contributor's Guide*.

The makefile variable `QUIET_BUILD` may be set to `1` for a less verbose build output, just like for building the programs.

Building documentation without compiling

The documentation can be built locally without compiling LilyPond binary, if LilyPond is already installed on your system.

From a fresh Git checkout, do

```
./autogen.sh   # ignore any warning messages
cp GNUmakefile.in GNUmakefile
make -C scripts && make -C python
nice make LILYPOND_EXTERNAL_BINARY=/path/to/bin/lilypond doc
```

This may break: if a new feature is added with a test file in input/regression, even the latest development release of LilyPond will fail to build the docs.

You may build the manual without building all the `input/*` stuff (i.e., mostly regression tests): change directory, for example to `Documentation/`, issue `make doc`, which will build documentation in a subdirectory `out-www` from the source files in current directory. In this case, if you also want to browse the documentation in its post-processed form, change back to top directory and issue

```
make out=www WWW-post
```

4.6.3 Testing LilyPond binary

LilyPond comes with an extensive suite that exercises the entire program. This suite can be used to test that the binary has been built correctly.

The test suite can be executed with:

```
make test
```

If the test suite completes successfully, the LilyPond binary has been verified.

More information on the regression test suite is found at Section "Regression tests" in *Contributor's Guide*.

4.7 Problems

For help and questions use `lilypond-user@gnu.org`. Send bug reports to `bug-lilypond@gnu.org`.

Bugs that are not fault of LilyPond are documented here.

Compiling on macOS

Here are special instructions for compiling under macOS. These instructions assume that dependencies are installed using MacPorts. (`https://www.macports.org/`) The instructions have been tested using Mac~OS~X 10.5 (Leopard).

First, install the relevant dependencies using MacPorts.

Next, add the following to your relevant shell initialization files. This is `~/.profile` by default. You should create this file if it does not exist.

```
export PATH=/opt/local/bin:/opt/local/sbin:$PATH
export DYLD_FALLBACK_LIBRARY_PATH=/opt/local/lib:$DYLD_FALLBACK_LIBRARY_PATH
```

At this point, you should verify that you have the appropriate fonts installed with your Ghostscript installation. Check `ls /opt/local/share/ghostscript/fonts` for: 'c0590*' files (.pfb, .pfb and .afm). If you don't have them, run the following commands to grab them from the Ghostscript SVN server and install them in the appropriate location:

```
svn export http://svn.ghostscript.com/ghostscript/tags/urw-fonts-1.0.7pre44/
sudo mv urw-fonts-1.0.7pre44/* /opt/local/share/ghostscript/fonts/
rm -rf urw-fonts-1.07pre44
```

Now run the `./configure` script. To avoid complications with automatic font detection, add

```
--with-fonts-dir=/opt/local/share/ghostscript/fonts
```

FreeBSD

To use system fonts, dejaview must be installed. With the default port, the fonts are installed in `usr/X11R6/lib/X11/fonts/dejavu`.

Open the file `$LILYPONDBASE/usr/etc/fonts/local.conf` and add the following line just after the `<fontconfig>` line. (Adjust as necessary for your hierarchy.)

```
<dir>/usr/X11R6/lib/X11/fonts</dir>
```

International fonts

On macOS, all fonts are installed by default. However, finding all system fonts requires a bit of configuration; see this post (https://lists.gnu.org/archive/html/lilypond-user/2007-03/msg00472.html) on the lilypond-user mailing list.

On Linux, international fonts are installed by different means on every distribution. We cannot list the exact commands or packages that are necessary, as each distribution is different, and the exact package names within each distribution changes. Here are some hints, though:

Red Hat Fedora

```
taipeifonts fonts-xorg-truetype ttfonts-ja fonts-arabic \
    ttfonts-zh_CN fonts-ja fonts-hebrew
```

Debian GNU/Linux

```
apt-get install emacs-intl-fonts xfonts-intl-.* \
    fonts-ipafont-gothic  fonts-ipafont-mincho \
    xfonts-bolkhov-75dpi xfonts-cronyx-100dpi xfonts-cronyx-75dpi
```

Using LilyPond Python libraries

If you want to use LilyPond's Python libraries (either running certain build scripts manually, or using them in other programs), add the path to the python subdirectory in your LilyPond source code (or git) tree to PYTHONPATH. Alternatively, add *prefix*/share/lilypond/2.26.0/python if LilyPond is installed in *prefix* (for example, /usr/local).

4.8 Concurrent stable and development versions

It can be useful to have both the stable and the development versions of LilyPond available at once. One way to do this on GNU/Linux is to install the stable version using the precompiled binary, and run the development version from the source tree. After running make all from the top directory of the LilyPond source files, there will be a binary called lilypond in the out directory:

```
<path to>/lilypond/out/bin/lilypond
```

This binary can be run without actually doing the make install command. The advantage to this is that you can have all of the latest changes available after pulling from git and running make all, without having to uninstall the old version and reinstall the new.

So, to use the stable version, install it as usual and use the normal commands:

```
lilypond foobar.ly
```

To use the development version, create a link to the binary in the source tree by saving the following line in a file somewhere in your $PATH:

```
exec <path to>/lilypond/out/bin/lilypond "$@"
```

Save it as Lilypond (with a capital L to distinguish it from the stable lilypond), and make it executable:

```
chmod +x Lilypond
```

Then you can invoke the development version this way:

```
Lilypond foobar.ly
```

TODO: ADD

- other compilation tricks for developers

4.8.1 Replacing the notation fonts in development versions

The instructions to install other notation fonts (see Section "Replacing the notation font" in *Notation Reference*) are slightly different if you call the `lilypond` binary directly from the build directory: instead of using a version directory name *X.Y.Z* in the path, you have to use `current` – LilyPond supports this special case to avoid re-installation in case you are updating the git repository, or if you are testing patches.

Assuming that you have compiled LilyPond in directory `~/lilybuild/`, additional font files should go into `~/lilybuild/out/share/lilypond/current/fonts/otf/` (this is usually a soft link to directory `~/lilybuild/mf/out/`). Note, however, that you have to repeat the installation of additional notation fonts after calling `make clean` (and a subsequent `make`), since this operation removes all `out/` subdirectories.

4.9 Build system

Version-specific Texinfo macros

- made with `scripts/build/create-version-itexi.py` and `scripts/build/create-weblinks-itexi.py`
- used extensively in the `WEBSITE_ONLY_BUILD` version of the website (made with `website.make`, used on lilypond.org)
- not (?) used in the main docs?
- the numbers in VERSION file: MINOR_VERSION should be 1 more than the last release, VERSION_DEVEL should be the last **online** release. Yes, VERSION_DEVEL is less than VERSION.

5 Documentation work

There are currently 11 manuals for LilyPond, not counting the translations. Each of them is available in split HTML (many small files), big HTML (a single file), PDF, and Info format. The documentation is written in a markup language called *Texinfo* – this allows us to generate different output formats from a single set of source files.

To allow multiple authors work simultaneously, we also use git (as previously discussed, see Chapter 3 [Working with source code], page 10) for the documentation.

5.1 Introduction to documentation work

Our documentation tries to adhere to our documentation policy (see Section 5.5 [Documentation policy], page 47). This policy contains a few items which may seem odd. One policy in particular is often questioned by potential contributors: we do not repeat material in the Notation Reference, and instead provide links to the "definitive" presentation of that information. Some people point out, with good reason, that this makes the documentation harder to read: if we repeated certain information in relevant places, readers would be less likely to miss that information.

That reasoning is sound, but we have two counter-arguments. First, the Notation Reference – one of *five* manuals for users to read – is already over 900 pages long. If we repeated material, we would easily need a few hundred pages more! Second, and much more importantly, LilyPond is an evolving project. New features are added, bugs are fixed, and bugs are discovered and documented. If features are discussed in multiple places, the documentation team must find every instance. Since the manual is so large, it is impossible for one person to have the location of every piece of information memorized, so any attempt to update the documentation will invariably omit a few places. This second concern is not at all theoretical; the documentation used to be plagued with inconsistent information.

If the documentation were targeted for a specific version – say, LilyPond 2.24.1 – and we had unlimited resources to spend on documentation, then we could avoid this second problem. However, since LilyPond evolves (and that is a very good thing!), and since we have quite limited resources, this policy remains in place.

A few other policies (such as avoiding the use of tweaks in the main portion of Notation Reference chapters 1 and 2) may also seem counter-intuitive, but they also stem from attempting to find the most effective use of limited documentation help.

Before undertaking any large documentation work, contributors are encouraged to contact the `lilypond-devel@gnu.org` mailing list.

5.2 `\version` in documentation files

Every documentation file that includes LilyPond code should begin with a `\version` statement, referencing a version of LilyPond that is consistent with the syntax of the contained code. Since the `\version` statement is not valid Texinfo input it must be put into a comment like this:

```
@c \version "2.24.1"
```

So, if you are adding LilyPond code not consistent with the current version header, you should

1. run `convert-ly` on the file using the latest version of LilyPond (which should, if everybody has done proper maintenance, not change anything);
2. add the new code;
3. modify the version number to match the new code.

5.3 Documentation suggestions

Small additions

For small additions to the documentation you might follow these steps.

1. Tell us where the addition should be placed. Please include both the section number and title (for example, 'LM 2.13 Printing lyrics').
2. Please write exact changes to the text.
3. A formal patch to the source code is *not* required; we can take care of the technical details.
4. Send the suggestions to the `bug-lilypond@gnu.org` mailing list as discussed in Section "Contact" in *General Information*.

Here is an example of a perfect documentation report:

```
To: bug-lilypond@gnu.org
From: helpful-user@example.net
Subject: doc addition

In LM 2.13 (printing lyrics), above the last line ("More options,
like..."), please add:

----
To add lyrics to a divided part, use blah blah blah.  For example,

\score {
  \notes {blah <<blah>> }
  \lyrics {blah <<blah>> }
  blah blah blah
}
----

In addition, the second sentence of the first paragraph is
confusing.  Please delete that sentence (it begins with "Users
often...") and replace it with this:
----
To align lyrics with something, do this thing.
----

Have a nice day,
Helpful User
```

Larger contributions

To replace large sections of the documentation, the guidelines are stricter. We cannot remove parts of the current documentation unless we are certain that the new version is an improvement.

1. Ask on the `lilypond-devel` mailing list if such a rewrite is necessary; somebody else might already be working on this issue!
2. Split your work into small portions; this makes it much easier to compare the new and old documentation.
3. Please prepare a formal git patch, ideally submitted as a *Merge Request* for our repository (see Section 3.3 [Lifecycle of a merge request], page 14).

Contributions that contain examples using overrides

We try to avoid overrides, tweaks, customer Scheme functions, etc., as much as possible in examples shown in the main text of the manuals, as there would be far too many, equally useful, candidates.

The correct way is to add your example, with appropriate explanatory text and categories, to the LilyPond Wiki, the successor of the LilyPond Snippet Repository (LSR). Snippets that have the 'Included in the official documentation' category can then be easily added as a *selected snippet* in the documentation. It will also appear automatically in the 'Snippets' manual. See Section 7.1 [Introduction to the LilyPond Wiki], page 64.

Snippets that *don't* have the 'Included in the official documentation' category will still be searchable and viewable within the Wiki, but will be not be included in the Snippets list or be able to be included as part of the main documentation.

Generally, any new snippets that have the 'Included in the official documentation' category are more carefully checked for syntax and formatting.

Announcing your snippet

Once you have followed these guidelines, please send a message to `lilypond-devel` with your documentation submissions.

We may edit your suggestion for spelling, grammar, or style, and we may not place the material exactly where you suggested, but if you give us some material to work with, we can improve the manual much faster.

Thanks for your interest!

5.4 Texinfo introduction and usage policy

5.4.1 Texinfo introduction

The markup language we use for writing LilyPond documentation is called Texinfo; you can see its manual here:

`https://www.gnu.org/software/texinfo/manual/texinfo/`

However, you don't need to read those documents. The most important thing to notice is that text is text. If you see a mistake in the text, you can fix it. If you want to change the order of something, you can cut and paste that stuff into a new location.

> **Note:** As a rule of thumb, follow the examples in the existing documentation. You can learn most of what you need to know from this; if you want to do anything fancy, discuss it on `lilypond-devel` first.

5.4.2 Documentation files

All manuals live in subdirectories of `Documentation/`*XX*, where '*XX*' is a two-letter language code like '`en`' for English. All non-English documents are translations of the English ones.

Here is a table of the most important user manuals together with the name of their master source files (the extension `.tely` stands for Texinfo + LilyPond code).

Learning Manual (LM)	`learning.tely`
Notation Reference (NR)	`notation.tely`
Music Glossary (MG)	`music-glossary.tely`
Application Usage (AU)	`usage.tely`
Extending Guide (EG)	`extending.tely`

Each chapter is put into a separate file, ending in `.itely` for files containing LilyPond code, and `.itexi` for files without LilyPond code (the 'i' in the file name extension stands for 'included'), located in a subdirectory associated with the manual (`learning/` for `learning.tely`, and so on); list the subdirectory of each manual to determine the file name of the specific chapter you wish to modify.

Developer manuals live in `Documentation/` too. Currently there is only one: the Contributor's Guide (`contributor.texi`) you are reading right now.

Many snippet files are part of the Notation Reference, and the Snippet List (SL), which holds all snippets, lives in `Documentation/` just like the manuals; its master file is called `snippets.tely`. For information about how to modify the snippet files and SL, see Chapter 7 [LilyPond Wiki work], page 64.

5.4.3 Sectioning commands

The Notation Reference uses section headings at four, occasionally five, levels.

level	**section command**
1	`@chapter`
2	`@section`
3	`@subsection`
4	`@unnumberedsubsubsec`
5	`@subsubsubheading`

The first three levels are numbered in HTML, the last two are not. A numbered section corresponds to a single HTML page in the split HTML documents.

The first four levels always have accompanying `@node` commands so they can be referenced; they are also included in the table of contents in HTML.

Most of the manual is written at level 4 under headings created with

```
@node Foo
@unnumberedsubsubsec Foo
```

Level 3 subsections are created with

```
@node Foo
@subsection Foo
```

Level 4 headings must be preceded by level 3 headings, and so on for level 3 and level 2. If this is not what is wanted, please use:

```
@subsubsubheading Foo
```

Leave two blank lines above a `@node`; this makes it easier to find sections in Texinfo code.

Do not use any `@`-commands within a `@node`. They may be used for any `@sub...` sections or headings, however.

```
not:
@node @code{Foo} bar
@subsection @code{Foo} bar

but instead:
@node Foo bar
@subsection @code{Foo} bar
```

Similarly, do not use punctuation in node names. If the heading text uses punctuation (in particular, colons and commas) simply leave this out.

```
@node We all love Bach Mozart and Gregorian chant
@subsection We all love Bach, Mozart, and Gregorian chant
```

As can be seen in the previous examples, we use *sentence-style* capitalization (*not* title case), which means that a heading starts with an uppercase letter, and you should only capitalize words in the remaining part of the heading if you would do so in an English sentence.

Backslashes must not be used in node names either.

```
@node set and unset
@subsection @code{\set} and @code{\unset}
```

With the exception of `@`-commands, `\`-commands and punctuation, the section name should match the node name exactly. If it happens that the heading starts with a command name that in turn starts with a lowercase letter, do not capitalize the command name in the node name.

Sectioning commands (`@node` and `@section`) must not appear inside an `@ignore ... @end ignore` block. Separate those commands with a space, i.e., '`@n ode`'.

5.4.4 Menus

A Texinfo *menu* is a `@menu ... @end menu` block that holds node names of all subsections of a section. By default, such blocks are auto-generated while creating Info and HTML output; in PDF output, they are not used. This means that it is not necessary to create menus normally.

The auto-generated menus simply use node names (and display the corresponding section names). If you want to add some description to one or more menu entries, however, you have to create the `@menu` block manually, to be put at the end of the current node, right before the first subsection node.

Assuming that the current section contains subsection node names 'foo', 'bar', and 'baz', the syntax is as follows.

```
@menu
* foo::    A very long description of an extremely
           important topic.
* bar::
* baz::    All you want to know about @code{baz}.
@end menu
```

As can be seen, the description of a menu entry might contain Texinfo commands, and it can be broken across multiple lines (in Info mode, the formatting of the `@menu` block is taken directly).

In the LilyPond documentation, most top-level menus contain descriptions.

5.4.5 LilyPond formatting

Here are some guidelines how to format LilyPond code in `@lilypond ... @end lilypond` blocks.

- Most LilyPond examples throughout the documentation can be produced with:

  ```
  @lilypond[verbatim,quote]
  ```

  If you need `\book{}` in your example then you must also include the `papersize=`*`X`* variable, where *`X`* is a paper size as defined in file `scm/paper.scm`. This is to avoid the default `a4` paper size being used and leaving too much unnecessary whitespace and potentially awkward page breaks in the PDFs.

  The preferred `papersize` values are `a5`, `a6`, or `a8landscape`.

  `a8landscape` works best for a single measure with a single title and/or a single tagline:

  ```
  @lilypond[papersize=a8landscape,verbatim]
  ```

```
\book {
  \header {
    title = "A scale in LilyPond"
  }
  \relative {
    c d e f
  }
}
@end lilypond
```

and can also be used to easily show features that require page breaks (i.e., page numbers) without taking large amounts of space within the documentation. Do not use the `quote` option with this paper size.

`a5` or `a6` paper sizes are best used for examples that have more than two measures of music or require multiple staves (i.e., to illustrate cross-staff features, right-hand and left-hand parts, etc.) and where `\book{}` constructions are required or where `a8landscape` produces an example that is too cramped. Depending on the example the `quote` option may need to be omitted.

In rare cases, other options may be used (or omitted), but ask first.

- For consistency with the existing documentation source code, please avoid using extra spacing either after or within the `@lilypond` parameters.

```
not:          @lilypond [verbatim, quote, fragment]
but instead:  @lilypond[verbatim,quote,fragment]
```

- Inspirational headwords are produced with:

```
@lilypondfile[quote,ragged-right,line-width=16\cm,staffsize=16]
{topic-headword.ly}
```

- LilyPond Wiki snippets are linked with:

```
@lilypondfile[verbatim,quote,ragged-right,texidoc,doctitle]
{name.ly}
```

- Use two spaces for indentation in LilyPond examples (no tabs).
- Try to avoid using `#'` or `#`` when describing context or layout properties outside of an `@example` or `@lilypond`, unless the description explicitly requires it.

  Example: "...setting the `transparent` property leaves the object where it is, but makes it invisible."
- If possible, only write one bar per line.
- If you only have one bar per line, you might omit bar checks. If you must put more than one bar per line (not recommended), then do include bar checks.
- `\override` tweaks should, if possible, also occur on their own line.

```
not:          \override TextScript.padding = #3 c1^"hi"
but instead:  \override TextScript.padding = #3
              c1^"hi"
```

- Avoid long stretches of input code. Nobody is going to read them in print. Create small examples. However, this does not mean it has to be minimal.
- Specify durations for at least the first note of every bar.
- If possible, end with a complete bar.
- Comments should go on their own line, and be placed before the line(s) to which they refer.
- For clarity, use '{' and '}' even if they are not technically required.

```
not:
```

```
\context Voice \repeat unfold 2 \relative c' {
  c2 d
}

but instead:

\context Voice {
  \repeat unfold 2 {
    \relative c' {
      c2 d
    }
  }
}
```

- Add a space around '{' and '}'.

```
not:          \chordmode{c e g}
but instead:  \chordmode { c e g }
```

- Use '{' and '}' for additional `\markup` format commands.

```
not:          c^\markup \tiny\sharp
but instead:  c^\markup { \tiny \sharp }
```

- Remove any space around '<' and '>' (except for situations like `<c e g-> >`, which would cause a syntax error otherwise).

```
not:           < c e g > 4
but instead:   <c e g>4
```

- Beam and slur marks should begin immediately after the first note (i.e., without a space in between), and end immediately after the last. Ties should also be attached without a space before the tilde sign.

```
a8\( ais16[ b cis( d] b) cis4~ b' cis,\)
```

- If you want to work on an example outside of the manual (for easier/faster processing), use this header.

```
\paper {
  indent = 0\mm
  line-width = 135.68\mm
}

\layout {}
```

  This is the default line width and indentation value used by `lilypond-book` (which converts the LilyPond code to PDF or PNG images) for `@lilypond` blocks with the `quote` option and no other overrides. Without the `quote` option, the line width is 156 mm.

5.4.6 Text formatting

- Lines should be less than 72 characters long. (We personally recommend writing with 66-char lines, but do not bother modifying existing material). See Section 5.4.7 [Syntax survey], page 42, for recommendations on how to use fixed-width fonts.

  The main reason for using short lines is that it makes it easy later on to add a forgotten `@code{...}` around a word, say, without the (aesthetical) need to reformat the text. Not reformatting a paragraph makes it much more straightforward to compare small changes with git repository viewers like `gitk` or `TortoiseGit`.

- Do not use tabs.

- Do not use spaces at the beginning of a line (except in `@example` or `@verbatim` environments), and do not use more than a single space between words. `texi2any` (which processes the Texinfo source files) copies the input lines verbatim without removing those spaces, and some output formats (plain text and Info) retain them in the generated output.
- Use two spaces after a period.
- In examples of syntax, use `@var{musicexpr}` for a music expression.
- Don't use `@rinternals{}` in the main text. If you're tempted to do so, you're probably getting too close to "talking through the code". If you really want to refer to a context, use `@code{}` in the main text and `@rinternals{}` in the `@morerefs` block.

5.4.7 Syntax survey

Comments

- `@c ...` – single-line comment.
- `@ignore` – multi-line comment:

```
@ignore
...
@end ignore
```

Cross-references

Enter the exact `@node` name of the target reference between the braces (for example, `@ref{Syntax survey}`). While cross references use the node name as an argument, they are set up for our documentation to display the corresponding section command in PDF and HTML output.

command	link target
`@ref`	current manual
`@rchanges`	Changes file
`@rcontrib`	Contributor's Guide
`@ressay`	Engraving Essay
`@rextend`	Extending Manual
`@rglos`	Music Glossary
`@rinternals`	Internals Reference
`@rlearning`	Learning Manual
`@rlsr`	a Snippet section
`@rprogram`	Application Usage
`@rnotation`	Notation Reference
`@rweb`	General Information webpage

All these commands also have a `@...named` version, which allows to specify the displayed text for the reference as a second argument. This is mainly used in translations, for example `@rlearningnamed{I'm hearing voices, J'entends des voix}`.

If you want to refer to an external manual as a whole instead of a specific section, use 'Top' as an argument. Example: `@rinternals{Top}`.

External links

- `@email{...}` – create a `mailto:` e-mail link.
- `@uref{URL[, link text]}` – link to an external URL:

```
@uref{https://www.gnu.org, The GNU project}
```

Fixed-width font

- `@code{...}`, `@samp{...}`

  Use the `@code{...}` command when referring to individual, language-specific tokens (keywords, commands, engravers, Scheme symbols, etc.) in the text. Ideally, a single `@code{...}` block should fit within one line in the PDF output.

  Use the `@samp{...}` command when you have a short example of user input (for example, one or two letters), unless it constitutes an entire `@item` by itself, in which case `@code{...}` is preferable. Otherwise, both should only be used when part of a larger sentence within a paragraph or `@item`. Do not use `@code{...}` or `@samp{...}` inside an `@example` block, and do not use either as a free-standing paragraph; use `@example` instead.

  A single, unindented line in the PDF has space for about 79 fixed-width characters (76 if indented). Within an `@item` there is space for about 75 fixed-width characters. Each additional level of `@itemize` or `@enumerate` shortens the line by about 4 columns.

  However, even short blocks of `@code{...}` and `@samp{...}` can run into the margin if the Texinfo line-breaking algorithm gets confused. Additionally, blocks that are longer than this may in fact print nicely; it all depends where the line breaks end up. If you compile the documentation by yourself, check the PDF output to make sure the line breaks are satisfactory.

  The Texinfo setting `@allowcodebreaks` is set to `false` in the manuals, so lines within `@code{...}` or `@samp{...}` blocks will only break at spaces, not at hyphens or underscores. If the block contains significant spaces, use `@w{@code{...}}` or `@w{@samp{...}}` to prevent unexpected line breaks.

  The Texinfo settings `txicodequoteundirected` and `txicodequotebacktick` are both set in the manuals, so backticks (`` ` ``) and apostrophes (`'`) placed within blocks of `@code`, `@example`, or `@verbatim` are not converted to left- and right-angled quotes (‘ ’) as they normally are within the text, so the apostrophes in ‘`@w{@code{\relative c''}}`’ will display correctly. However, these settings do not affect the PDF output for anything within a `@samp` block (even if it includes a nested `@code` block), so entering ‘`@w{@samp{\relative c''}}`’ wrongly produces ‘`\relative c’’`’ in PDF. Consequently, if you want to use a `@samp{...}` block which contains backticks or apostrophes, you should instead use ‘`@q{@code{...}}`’ (or ‘`@q{@w{@code{...}}}`’ if the block also contains significant spaces).

- `@command{...}` – Use when referring to command-line commands within the text (e.g., ‘`@command{convert-ly}`’). Do not use inside an `@example` block.

- `@example` – Use for examples of program code. Do not add extraneous indentation (i.e., don't start every line with whitespace). Use the following layout (notice the use of blank lines). Omit the `@noindent` if the text following the example starts a new paragraph:

  ```
  ...text leading into the example...

  @example
  ...
  @end example

  @noindent
  continuation of the text...
  ```

  Individual lines within an `@example` block should not exceed 74 characters; otherwise they will run into the margin in the PDF output, and may get clipped. If an `@example` block is part of an `@item`, individual lines in the `@example` block should not exceed 70 columns. Each additional level of `@itemize` or `@enumerate` shortens the line by about 4 columns.

For long command-line examples, if possible, use a trailing backslash to break up a single line, indenting the next line with 2 spaces. If this isn't feasible, use '`@smallexample ... @end smallexample`' instead, which uses a smaller font size. Use `@example` whenever possible, but if needed, `@smallexample` can fit up to 90 characters per line before running into the PDF margin. Each additional level of `@itemize` or `@enumerate` shortens a `@smallexample` line by about 5 columns.

- `@file{...}` – Use when referring to file names, file name extensions, and directories in the text. Do not use inside an `@example` block.
- `@option{...}` – Use when referring to command-line options in the text (e.g., '`@option{--format}`'). Do not use inside an `@example` block.
- `@verbatim` – Print the block exactly as it appears in the source file (including whitespace, etc.), without handling any Texinfo commands. The characters '`@`', '`{`', and '`}`' don't need to be quoted with a leading '`@`' character. For program code examples, use `@example` instead. `@verbatim` uses the same format as `@example`.

  Individual lines within an `@verbatim` block should not exceed 74 characters; otherwise they will run into the margin in the PDF output, and may get clipped. If an `@verbatim` block is part of an `@item`, individual lines in the `@verbatim` block should not exceed 70 columns. Each additional level of `@itemize` or `@enumerate` shortens the line by about 4 columns.

Indexing

Use the following two commands.

- `@cindex ...` – for the general index
- `@funindex ...` – for commands and properties like `\bar` or `left-margin`

Here are some rules how index entries should look like.

- Only capitalize the first word of a `@cindex` entry if you would do so in the middle of an English sentence. Examples:

  ```
  @cindex ancient clef
  @cindex Kievan clef
  ```

  `@funindex` entries are written as-is; don't omit the leading backslash if there is one.
- Use singular forms as much as possible. After a comma, use whatever looks better. Examples:

  ```
  @cindex clef
  @cindex fingering instruction, for chords
  ```
- Permute index entries if it makes sense. Example:

  ```
  @cindex ancient note head
  @cindex note head, ancient
  ```
- Try to make entries fit into groups so that the printed index looks like this:

  ```
  ...
  text, framing
  text, horizontal alignment
  text, in columns
  text, in volta bracket
  text, justified
  ...
  ```
- Don't insert `@funindex{\foo}` and `@cindex{\foo}` simultaneously.
- If both `foo` and `\foo` need to be indexed with `@funindex` you have to use the `@funindexpre` or `@funindexpost` command: `@funindexpre foo` gets sorted before `@funindex \foo`, and `@funindexpost \foo` gets sorted after `@funindex foo`. Example:

  ```
  @funindex [
  ```

```
@funindexpost \[
```

- If you mention entities in a `@cindex` entry that would normally be entered with `@funindex`, use `@code` to mark them. Example:

  ```
  @cindex @code{\context}, in @code{\layout} block
  ```

- To get a literal '{' or '}' in an index, write `@{` and `@}`, respectively.

- As of November 2022, if an index entry starts with an accented character, use a Texinfo accent macro instead of the real character. For example, an index entry for 'Äolisch' should be entered as

  ```
  @cindex @"Aolisch
  ```

  to circumvent a problem with `texindex` (used by Texinfo to sort and unify index entries in PDF output): this program currently has no support for locale-specific collation. In the above example, the entry is now sorted as 'Aolisch'.

  In case this is not sufficient it is always possible to explicitly specify a sorting key using the `@sortas` command: Assuming that entries starting with letter 'ä' must be sorted after all entries starting with letter 'a', writing

  ```
  @cindex @sortas{azzzAolisch} Äolisch
  ```

  would make this work. Unfortunately, this trick doesn't create an initial letter in the printed index for entries starting with 'Ä'.

Lists

- `@enumerate` – create an ordered list (with numbers). Always put '`@item`' on its own line. As an exception, if all the items in the list are short enough to fit on single lines, placing them on the '`@item`' lines is also permissible. '`@item`' and '`@end enumerate`' should be preceded by a blank line except for short, compact entries (this is for Info file generation).

  ```
  @enumerate

  @item
  A long multi-line item like this one must begin
  on a line of its own and all the other items in
  the list must do so too.

  @item
  Even short ones

  @end enumerate
  ```

  ```
  @enumerate

  @item Short item

  @item Short item

  @end enumerate
  ```

- `@itemize` – create an unordered list (with bullets). Use the same format as `@enumerate`. Do not use '`@itemize @bullet`'.

Special characters

Note: In Texinfo, the backslash is an ordinary character, and is entered without escaping (e.g. 'The @code{\foo} command'). However, within double-quoted Scheme and/or LilyPond strings, backslashes (including those ending up in Texinfo markup) need to be escaped by doubling them:

```
(define (foo x)
  "The @code{\\foo} command..."
  ...)
```

- `--`, `---` – create an en dash (–) or an em dash (—) in the text. To print two or three literal hyphens in a row, wrap one of them in a `@w{...}` (e.g., '`-@w{-}-`'). Note that the LilyPond manuals almost never use em dashes in text.
- `@@`, `@{`, `@}` – create an at-sign ('@'), a left brace ('{'), or a right brace ('}').
- `@tie{}` – create a *variable-width*, non-breaking space in the text (use '`@w{ }`' for a single *fixed-width*, non-breaking space). Variables or numbers that consist of a single, unquoted character (probably followed by a punctuation mark) should be tied properly, either to the previous or to the next word depending on context. Example: '`... item@tie{}3 in the previous list ...`'

Miscellany

- `@notation{...}` – refer to pieces of notation, e.g., '`@notation{clef}`'. Also use for specific lyrics ('`the @notation{A - men} is centered`'). Only use once per subsection per term.
- `@q{...}` – single quotes. Used for 'vague' terms. This is the preferred quoting mechanism in the LilyPond manuals.
- `@qq{...}` – double quotes. Used for actual quotes ("he said") or for introducing special input modes.
- `@var{...}` – use for metasyntactic variables (such as *foo*, *bar*, *arg1*, etc.). In most cases, when the `@var{...}` command appears in the text (and not in an `@example` block) it should be wrapped with an appropriate code-highlighting Texinfo command (such as `@code`, `@samp`, `@file`, `@command`, etc.). For example: '`@code{@var{foo}}`', '`@file{@var{myfile.ly}}`', '`@samp{git switch @var{branch}}`', etc. This improves readability in the PDF and HTML output.
- `@version{}` – return the current LilyPond version string. Use '`@w{@version{}}`' if it's at the end of a line (to prevent an ugly line break in PDF); use '`@w{"@version{}"}`' if you need it in quotes.
- `@w{...}` – do not allow any line breaks.
- `@warning{...}` – produce a "Note: " box. Use for important messages.

5.4.8 Other text concerns

- References should occur at the end of a sentence; for more information see the Texinfo manual (`https://www.gnu.org/software/texinfo/manual/texinfo/`). Ideally this should also be the final sentence of a paragraph, but this is not required. Any link in a doc section must be duplicated in the `@morerefs` section at the bottom.
- Introducing examples should be done with

```
. (i.e., finish the previous sentence/paragraph)
: (i.e., 'in this example:')
, (i.e., 'may add foo with the blah construct,')
```

  The method "sentence runs directly into the example" is discouraged.

- Write abbreviation and acronyms in uppercase letters, e.g., HTML, DVI, MIDI.
- Colon usage
  1. To introduce lists.
  2. When beginning a quote: “So, he said,...”.

     This usage is rarer. Americans often just use a comma.
  3. When adding a defining example at the end of a sentence.
- Non-ASCII characters should be directly used; this is, don’t say ‘`Ba@ss{}tuba`’ but ‘`Baßtuba`’. This ensures that all such characters appear in all output formats. There are limitations for PDF output, though, because the used fonts only support a relatively small number of Unicode characters.[1]

5.5 Documentation policy

5.5.1 Books

The five main parts of the documentation are the Learning Manual, the Notation Reference, the Application Usage, the Music Glossary, and the Internals Reference.

- Learning Manual

  The LM is written in a tutorial style which introduces the most important concepts, structure and syntax of the elements of a LilyPond score in a carefully graded sequence of steps. Explanations of all musical concepts used in the manual can be found in the Music Glossary, and readers are assumed to have no prior knowledge of LilyPond. The objective is to take readers to a level where the Notation Reference can be understood and employed to both adapt the templates in the Appendix to their needs and to begin to construct their own scores. Commonly used tweaks are introduced and explained. Examples are provided throughout which, while being focused on the topic being introduced, are long enough to seem real in order to retain the readers’ interest. Each example builds on the previous material, and comments are used liberally. Every new aspect is thoroughly explained before it is used.

  Users are encouraged to read the complete Learning Manual from start to finish.
- Notation Reference

  This is a (hopefully complete) description of LilyPond’s input notation. Some material from here may be duplicated in the Learning Manual (for teaching), but consider the NR to be the ‘definitive’ description of each notation element, with the LM being an ‘extra’. The goal is *not* to provide a step-by-step learning environment – do not avoid using notation that has not be introduced previously in the NR (for example, use `\break` if appropriate). The NR is written in formal technical writing style.

  Avoid duplication. Although users are not expected to read this manual from start to finish, they should be familiar with the material in the Learning Manual (particularly “Fundamental Concepts”), so do not repeat that material in each section of this book. Also watch out for common constructs, like ‘`^`’, ‘`-`’, and ‘`_`’ for directions – those are explained in NR chapter 5. In NR chapter 1, for example, you can use a reference and write:

  ```
  Dynamics may be manually placed above or below the staff, see
  @ref{Direction and placement}.
  ```

  Most tweaks should be added to snippets in the LilyPond Wiki and not placed directly in the `.itely` file. In some cases, tweaks may be placed in the main text, but ask about this first.

[1] This might change in the future since recent versions of Texinfo support output to LaTeX, which doesn’t have this limitation.

Finally, you should assume that users know what the notation means; explaining musical concepts happens in the Music Glossary.

- Application Usage

  This manual gives information about calling and using the `lilypond` program itself and other tools related to it (in particular `convert-ly` and `lilypond-book`), issues related to differences in the used operating system, some pointers to external programs, etc. This manual is written in formal technical writing style.

  Users are not expected to read this manual from start to finish.

- Music Glossary

  Information about the music notation itself. Explanations and translations about notation terms go here.

  Users are not expected to read this manual from start to finish.

- Internals Reference

  This manual is automatically generated from documentation strings embedded in the source code. It provides an in-depth reference to almost all low-level details of LilyPond.

  Users are not expected to *read* this manual at all. It should rather be used like a dictionary to look up, say, all properties and sub-properties of a slur. The writing style is extremely terse and technical (sometimes too terse, admittedly).

5.5.2 Section organization

- The order of headings inside documentation sections should be:

```
documentation text

@predefined
@endpredefined

@snippets

@morerefs
@endmorerefs

@knownissues
```

- You *must* include a `@morerefs ... @endmorerefs` block.
  - The order of items inside the `@morerefs` block is

```
Music Glossary:
@rglos{foo},
@rglos{bar}.

Learning Manual:
@rlearning{baz},
@rlearning{foozle}.

Notation Reference:
@rnotation{faazle},
@rnotation{boo}.

Application Usage:
@rprogram{blah}.
```

```
Essay on automated music engraving:
@ressay{yadda}.

Extending LilyPond:
@rextend{frob}.

Installed Files:
@file{path/to/dir/blahz}.

Snippets:
@rlsr{section}.

Internals Reference:
@rinternals{fazzle},
@rinternals{booar}.
```

  - If there are multiple entries, separate them by commas only and do not use the word 'and'. If there are no references to a specific manual, omit it.
  - Always end with a period.
  - Place each link on a new line as above; this makes it much easier to add or remove links. In the output, they appear on a single line.
  - Any new concepts or links which require an explanation should appear as a full sentence(s) in the main text.
  - Don't insert an empty line between `@morerefs` and the first entry! Otherwise there is excessive vertical space in the PDF output.
- Use `@ref{...}` instead of the abovementioned reference commands if the link is within the same manual.
- `@predefined ... @endpredefined` is for commands defined in files `ly/*-init.ly`.
- Do not include any real information in second-level sections (for example, '1.1 Pitches'). A first-level section may have introductory material, but other than that all material goes into third-level sections (for example, '1.1.1 Writing Pitches').
- The `@knownissues` part should usually not describe any issues that are in LilyPond's bug tracker. The goal is rather to discuss any overall architecture or syntax decisions, which may be interpreted as bugs. Normal bugs should not be discussed here, because we have so many of them that it would be a huge task to keep `@knownissues` current and accurate all the time.

5.5.3 Checking cross-references

Cross-references between different manuals are heavily used in the documentation, but they do not cause errors during the compilation – the documentation generator, `texi2any`, only reports invalid cross-references within the same manual. However, if you compile the documentation, a script called `check_texi_refs.py` can help you with checking and fixing these cross-references.

To make this work properly you have to configure LilyPond for an in-tree build (see Section 4.4.2 [Running `autogen.sh`], page 26), followed by calling `make` and `make doc`.

Normally, you don't call `check_texi_refs.py` by yourself; instead, two `make` targets are provided for this task. To call them, first change the current directory to the LilyPond source tree where the documentation was built, then enter the `Documentation` directory and run:

```
make check-xrefs
make fix-xrefs
```

Be careful with the second command since it can change documentation files without further asking.

In case you have to fix cross-references in generated documentation like the Internals Reference you must locate the corresponding source code files by yourself. Scan the directories `scm/` for Scheme code and `lily/` for C++ code. See Section 5.6.2 [Searching], page 51.

5.5.4 General writing

- Do not forget to create `@cindex` entries for new sections of text. Commands usually need a `@funindex` entry, for example,

  ```
  @cindex pitches, writing in different octaves
  @funindex \relative
  ```

  Do not add `@code{...}` around the `@funindex` argument; this is handled internally. While `@cindex` entries get added to the main index only, `@funindex` entries are added to both the command index and the main index. Both index commands should go in front of the actual material (each on a separate line).
- `@cindex` entries should not be capitalized, i.e.,

  ```
  @cindex time signature
  ```

  is preferred instead of "Time signature". Only use capital letters for musical terms which demand them, e.g., "D.S. al Fine".
- For Scheme function index entries, only include the final part, i.e.,

  ```
  @funindex modern-voice-cautionary
       and NOT
  @funindex #(set-accidental-style modern-voice-cautionary)
  ```
- Use American spelling. LilyPond's internal property names use this convention.
- Here is a list of preferred terms to be used:
  - *Simultaneous*, NOT concurrent.
  - *Measure*: the unit of music.
  - *Bar line*: the symbol delimiting a measure, NOT barline.
  - *Note head*, NOT notehead.
  - *Chord construct*, NOT just chord (when referring to `<...>`).
  - *Staff*, NOT stave.
  - *Staves*, NOT Staffs: phrases such as

    ```
    multiple @internalsref{Staff}s
    ```

    should be rephrased to

    ```
    multiple @internalsref{Staff} contexts
    ```

5.5.5 Technical writing style

The topics discussed here refer to the NR. The LM uses a more gentle, colloquial style.

- Do not refer to LilyPond in the text. The reader knows what the manual is about. If you do, capitalization is LilyPond.
- If you explicitly refer to 'lilypond' the program (or any other command to be executed), write `@command{lilypond}`.
- Do not explicitly refer to the reader or user. There is no one else besides the reader and the writer.
- Avoid contractions (don't, won't, etc.). Spell the words out completely.
- Avoid abbreviations, except for commonly used abbreviations of foreign language terms such as 'etc.' and 'i.e.' (which should be both followed by a comma if mid sentence, by the way).

- Avoid fluff ("Notice that," "as you can see," "Currently,").
- The use of the word 'illegal' is inappropriate in most cases. Say 'invalid' instead.

5.6 Tips for writing documentation

5.6.1 Working on subsections

In the NR, we highly recommend focusing on one subsection at a time. For each subsection,

- check the mundane formatting. Are the headings (`@predefined`, `@morerefs`, etc.) in the right order?
- add any appropriate index entries.
- check the links in the `@morerefs` section – links to the Music Glossary, the Internals Reference, and other NR sections are the main concern. Check for potential additions.
- move material that makes sense if processed stand-alone into the LilyPond Wiki as a snippet, then delete the material from the `.itely` file and replace it with a `@lilypondfile` command.
- check the examples and descriptions. Do they still work? **Do not** assume that the existing text is accurate or complete; some parts of the manual are highly out of date due to the constant lack of manpower.
- is the material in the `@knownissues` block still accurate?
- can the examples be improved (for example, made more explanatory), or is there any missing information? Feel free to ask specific questions on the `lilypond-user` mailing list; a couple of people claimed to be interesting in being "consultants" who would help with such questions.

  We favor short text explanations with good examples – "an example is worth a thousand words". However, producing good, tiny LilyPond examples can be quite time-consuming; making easily-understandable examples is much harder than it looks.

Tweaks

In general, any `\set` or `\override` command should go in the "selected snippets" section, which means that they should be added to the LilyPond Wiki and not to the `.itely` file. For some cases, the command obviously belongs in the "main text" (i.e., not inside `@predefined` or `@morerefs` or whatever) – instrument names are a good example of this:

```
\set Staff.instrumentName = "foo"
```

On the other side of this,

```
\override Score.Hairpin.after-line-breaking = ##t
```

clearly belongs to a snippet in the LilyPond Wiki.

One place where a documentation writer can profitably spend time writing or upgrading tweaks is creating code to deal with known issues. It would be ideal if every significant known issue had a workaround to avoid the difficulty.

See also

Section 7.2 [Adding and editing snippets], page 64.

5.6.2 Searching

If you are working with the git repository, the most useful tool on the command line to search text is `git grep`, which recursively scans the repository's files for strings using *regular expressions* (regex). This manual cannot give an introduction into the use of regular expressions; there are plenty of resources in the internet that may help you.

Files not managed by git in a repository (for example, all files generated during compilation or building the documentation) cannot be searched with `git grep`, though. In such cases you might use the standard `grep` tool instead, which has almost exactly the same syntax.

Another limitation of both `grep` and `git grep` is their inability to search a string across multiple lines,[2] which would be extremely helpful in finding arguments of Texinfo commands. A solution is to use a variant of grep called `pcregrep` (or its newer version `pcre2grep` – the acronym PCRE stands for Perl Compatible Regular Expressions). You most likely have to install this program; look for packages called 'pcre-tools', 'pcre2-tools', or something similar.

As an example, let's assume that you want to find all occurrences of `@rweb{Easier editing}` within `Documentation/en/`. After changing to this directory, a search with

```
git grep '@rweb{Easier\s*editing}'
```

might return the following.

```
usage/external.itely:editors are listed in @rweb{Easier editing}.
usage/external.itely:are listed in @rweb{Easier editing}.
```

[The string `\s*` means to search for whitespace (`\s`) zero or more times in succession (`*`).]

On the other hand, a search with

```
pcregrep -r -M '@rweb{Easier\s*editing}' .
```

shows one more hit.

```
./learning/installing.itely:For more information, see @rweb{Easier
editing}.
./usage/external.itely:editors are listed in @rweb{Easier editing}.
./usage/external.itely:are listed in @rweb{Easier editing}.
```

[Option `-r` enables recursive searching of the current directory ('.'), option `-M` activates multi-line searching.]

5.7 Scripts to ease documentation work

Since the whole LilyPond documentation build process is slow, intimidatingly complex, and hard to master even for experts, tools have been developed over time to help authors handle the most daunting tasks.

5.7.1 Building only one section of the documentation

In order to save build time, a script is available to build and immediately display only one section of the documentation in English with a default HTML appearance.

Call the script as follows.

```
scripts/auxiliar/doc-section.sh manual section
```

section is the name of the file containing the section to be built, and *manual* is replaced by the name of the directory containing the section. So, for example, to build section 1.1 of the Notation Reference, use the command:

```
scripts/auxiliar/doc-section.sh notation pitches
```

You can then see the generated document for the section at

```
build/tempdocs/pitches/out/pitches.html
```

To make this actually work it is necessary to first configure and compile LilyPond. Furthermore, the script listens to some environment variables.

- The location of the top-level directory of LilyPond's git repository can be set with the `LILYPOND_GIT` environment variable. If not specified, the script tries to auto-detect its location.

[2] There is limited support for multi-line searching with recent versions of standard `grep`. However, it cannot display context around the matches for technical reasons.

- The location of the compilation directory can be set with the `LILYPOND_BUILD_DIR` environment variable. If not specified, the `build/` directory in the git repository's top-level directory is tried.
- The location of the script's output directory can be set with the `LILYPOND_TEMPDOCS` environment variable. If not specified, it uses the `tempdocs/` subdirectory within the compilation directory.
- The used browser to display the final HTML page defaults to Firefox; this can be changed by setting the standard `BROWSER` environment variable (which you probably have already set in your environment).

If these variables are set up correctly, you can call the script from any directory on your computer. If you configure the build process as recommended (see Section 4.4 [Configuring `make`], page 26), i.e., building in the git repository's top-level subdirectory called `build/`, you don't even need to set any of those environment variables.

This script will not work for building sections of the Contributor's Guide. To do that, use:

```
scripts/auxiliar/cg-section.sh section
```

where *`section`* is the name of the file containing the section(s) to be built. For example, to build chapter 5 of the Contributor's Guide, use:

```
scripts/auxiliar/cg-section.sh doc-work
```

The `cg-section.sh` script uses the same environment variables and corresponding default values as `doc-section.sh`.

5.7.2 Updating documentation with `convert-ly`

Don't. This should be done by programmers when they add new features. If you notice that it hasn't been done, complain to `lilypond-devel`.

5.8 Documentation strings in the Internals Reference

Material in the Internals Reference is generated automatically from our source code. Any documentation work on the IR therefore requires modifying files in the `scm/` or `lily/` directories. Texinfo formatting should be used in these documentation strings.

Most documentation writers never touch these, though. If you want to work on them, please ask for help.

5.9 Translating the documentation

5.9.1 Getting started with documentation translation

First, get the sources from the git repository, see Chapter 3 [Working with source code], page 10.

Translation requirements

Working on LilyPond documentation translations requires the following pieces of software, in order to make use of dedicated helper tools:

- Python 3.8 or higher,
- GNU make,
- gettext,
- git.

It is not required to build LilyPond and the documentation to translate the documentation. However, if you have enough time and motivation and a suitable system, it can be very useful to

build at least the documentation so that you can check the output yourself and more quickly; if you are interested, see Chapter 4 [Compiling], page 20.

Before undertaking any large translation work, contributors are encouraged to contact the `lilypond-devel` mailing list.

Which documentation can be translated

The makefiles and scripts infrastructure currently supports translation of the following documentation:

- the website, the Learning Manual, the Notation Reference and Application Usage
- the Changes document, the Music Glossary, the Essay

Support for translating the following pieces of documentation is not yet available.

- automatically generated documentation: markup commands, predefined music functions;
- the Internals Reference.

Starting translation in a new language

At top of the source directory, do

```
./autogen.sh
```

or (if you want to install your self-compiled LilyPond locally)

```
./autogen.sh --prefix=$HOME
```

If you want to compile LilyPond – which is required to build the documentation, but is not required to do translation only – fix all dependencies and rerun `./configure` (with the same options as for `autogen.sh`).

Then `cd` into `Documentation/` and run

```
make ISOLANG=MY-LANGUAGE new-lang
```

where *MY-LANGUAGE* is the language's two-letter ISO 639 code. This `make` call reduces the English documentation files to bare skeleton files that are eventually moved to the directory `Documentation/`*MY-LANGUAGE*`/`, exactly mimicking the directory and file structure of `Documentation/en/`.

However, all include files still have the `en/` prefix, making it load the English documentation. If you plan to translate, say, file `foo.itely`, and your language code is 'xy'; you should replace

```
@include{en/foo.itely}
```

with

```
@include{xy/foo.itely}
```

so that your translated text gets incorporated into the translated document.

Finally, add entries for the new language to the following files:

```
python/langdefs.py
Documentation/lilypond-lang.init
Documentation/webserver/lilypond.org.htaccess
scripts/build/create-weblinks-iteci.py
ROADMAP
```

A Texinfo language definition file is also needed:

```
Documentation/tex/txi-MY-LANGUAGE.tex
```

The Texinfo distribution itself contains a large number of such language definition files; take the one you need and simply copy it. If you are translating to a language for which no such file is available and you are going to write it, please contribute it to the Texinfo project, too!

5.9.2 Documentation translation details

Please follow all the instructions with care to ensure quality work.

All files should be encoded in UTF-8.

Files to be translated

A translation of file `Documentation/en/foo/bar.baz` should be stored in file `Documentation/MY-LANGUAGE/foo/bar.baz`. Unmentioned files should not be translated.

The table below list recommended priorities (lower values mean higher priority) of files to be translated. Files of priority 1 should be submitted along all files generated by starting a new language in the same commit and thus be a unique patch. Translation of files marked with priority 2 should be committed to the git repository at the same time and thus sent in a single patch. Priority 1 files are required before requesting a language-specific mailing list `lilypond-xyz@gnu.org`. Files marked with priority 3 or lower may be submitted individually. For knowing how to commit your work to the git repository, preferably as a Merge Request, see Chapter 3 [Working with source code], page 10.

Only add translated files to the git repository! All other, untranslated files can be safely deleted. If necessary, skeleton files can be regenerated by calling the `new-lang` make target again (this doesn't overwrite existing files).

1 The website: `web.texi`, `web/introduction.itexi`, and `web/download.itexi`. Additionally, also translate `macros.itexi` and `search-box.ihtml`.
2 The tutorial: `web/manuals.itexi`, `learning.tely`, `learning/installing.itely`, `learning/tutorial.itely`, and `learning/common-notation.itely`.
3 Fundamental concepts in `learning/fundamental.itely`, as well as `usage.tely`, `usage/running.itely`, `usage/updating.itely`, and `web/community.itexi`.
4 The Changes file: `changes.tely`.
5 More useful information: `learning/tweaks.itely`, `learning/templates.itely`, and `usage/suggestions.itely`.
6 The Notation Reference: `notation.tely`, all of `notation/*.itely`, and the snippets' titles and descriptions.
7 More tools: `usage/lilypond-book.itely` and `usage/external.itely`.
8 The Essay and the guide to extend LilyPond: `essay.tely` and `essay/*.itely`, as well as `extending.tely` and `extending/*.itely`.
9 The Music Glossary: `music-glossary.tely`.
10 LilyPond Snippets: `snippets.tely`. A large portion of them is also included in the NR.

A special case is file `Documentation/po/MY-LANGUAGE.po`, which holds strings to translate. Currently, there are two helper scripts that access it during a documentation build:

- `www_post.py`, to post-process HTML pages. Some messages to translate are in its module `postprocess_html.py`, and strings in the `.po` file tagged with this file name have priority 1 for translation.
- `lilypond-book`, to automatically translate comments within `@lilypond` blocks. In the `.po` file, such strings are tagged with '(comment)', and translating such strings has a very low priority.

  Strings tagged with other markers like '(variable)' and '(context id)' can be safely ignored for the time being; the same is true for strings tagged as being a `@node` or a sectioning command like `@appendix`.

  Note, however, that this `lilypond-book` feature is currently broken.

Do not mix up the `Documentation/po/` and `po/` directories! The latter holds translations of messages emitted by `lilypond` (the program) and various other tools; they are maintained exter-

nally by the Free Translation Project (`https://translationproject.org/domain/lilypond.html`).

Translating the website and other Texinfo documentation

Every piece of text should be translated in the source file, except Texinfo comments, text in `@lilypond` blocks and a few cases mentioned below.

Node names are not translated, only the section titles are. That is, every piece in the original file like

```
@node Foo bar
@section_command Bar baz
```

should be translated as

```
@node Foo bar
@section_command translation of Bar baz
```

The argument of `@rglos` commands and the first argument of `@rglosnamed` commands must not be translated, as it is the node name of an entry in the Music Glossary.

Every time you translate a node name in a cross-reference, i.e., the argument of commands like `@ref` or `@rprogram` (see [Cross-references], page 42, for the complete list) or the first argument of their `@...named` variants, you should make sure the target node is defined in the correct source file. If you do not intend to translate the target node right now, you should at least write the node definition in the expected source file and define all its parent nodes; for each node you have defined this way but have not translated, insert a line that contains `@untranslated`. That is, you should end up for each untranslated node with something like

```
@node Foo bar
@section_command translation of Bar baz

@untranslated
```

(the `new-lang` target does this in the skeleton files).

Please consider that it may not make sense to translate everything in some Texinfo files, and that you may deviate from the original text if necessary or useful. For instance, in the translation of the website section "Community", you may add information on the community in your language and give links to existing public forums or mailing lists.

- Section "Bug reports" in *General Information*: this page should be translated only if you know that every bug report sent on your language's mailing list or forum will be handled by someone who will translate it to English and send it to `bug-lilypond` or add an issue in the tracker, then translate back the reply from developers. [Today, with the help of automatic translators available in the internet, this is less of a concern.]
- Section "Help us" in *General Information*: this page should be translated very freely, and possibly not at all – a translation makes only sense if there are enough people interested in contributing language-specific documentation work. For actually working on the code you have to communicate with the developers in English.

In any case, please mark in your work the sections which do not result from the direct translation of a piece of English translation, using comments, i.e., lines starting with '`@c`'.

Some pieces of text manipulated by build scripts that appear in the output are translated in a `.po` file; this has been discussed in the previous section.

Take care of using typographic rules for your language, especially in `macros.itexi`.

If you wonder whether a word, phrase or larger piece of text should be translated, whether it is an argument of a Texinfo command or a small piece sandwiched between two Texinfo commands,

try to track whether and where it appears in PDF and/or HTML output as visible text. This piece of advice is especially useful for translating `macros.itexi`.

Please keep verbatim copies of music snippets (in `@lilypond` blocks). However, some music snippets containing text that shows in the rendered music, and sometimes translating this text really helps the user to understand the documentation; in this case, and only in this case, you may as an exception translate text in the music snippet, and then you must add a line immediately before the `@lilypond` block, starting with

```
@c KEEP LY
```

Otherwise the music snippet would be reset to the same content as the English version at next `make snippet-update` run – see [Updating documentation translation], page 58.

When you encounter

```
@lilypondfile[...,texidoc,...]{filename.ly}
```

in the source, open `Documentation/snippets/`*`filename`*`.ly`, translate the `texidoc` header field it contains, wrap it with `texidoc`*`MY-LANGUAGE`*`= "..."`, and write it into `Documentation/`*`MY-LANGUAGE`*`/texidocs/`*`filename`*`.texidoc`. Additionally, you may translate the snippet's title in the `doctitle` header field in case `doctitle` is a fragment option used in `@lilypondfile`; you can do this exactly the same way as `texidoc`. For instance, `Documentation/es/texidocs/`*`filename`*`.texidoc` may contain

```
doctitlees = "Spanish title baz"
texidoces = "
Spanish translation blah
"
```

The argument to `doctitle`*`XX`* must not contain a line break; it is directly passed on to Texinfo, expecting the title on single line (which gets typeset in more than a single line if necessary, though).

`@example` blocks need not be verbatim copies; it often makes sense to translate variable names, file names, and comments.

Finally, please carefully apply every rule exposed previously; see Section 5.4 [Texinfo introduction and usage policy], page 37, and Section 5.5 [Documentation policy], page 47. If one of these rules conflicts with a rule specific to your language, please ask on the `lilypond-devel@gnu.org` list.

Adding a Texinfo manual

In order to start translating a new manual you might use the skeleton files generated by the `new-lang` make target, see [Starting translation in a new language], page 54. You might also copy the corresponding English files to your language directory instead and translate them.

For example, if you want to translate the first chapter of the Learning Manual:

```
cp Documentation/en/learning.tely \
     Documentation/MY-LANGUAGE/learning.tely
cp Documentation/en/learning/tutorial.itely \
     Documentation/MY-LANGUAGE/learning/tutorial.itely
```

5.9.3 Documentation translation maintenance

Several tools have been developed to make translations maintenance easier. These helper scripts make use of the power of git, the version control system used for LilyPond development.

You should use them whenever you would like to update the translation in your language, which you may do at the frequency that fits your and your co-translators' respective available times. In the case your translation is up-to-date (which you can discover in the first subsection below), it is enough to check its state every one or two weeks. If you feel overwhelmed by

the quantity of documentation to be updated, see [Maintaining without updating translations], page 60.

Check state of translation

> **Note:** Translation helper scripts will work only if you have configured LilyPond to be built in-tree, see Section 4.4.2 [Running `autogen.sh`], page 26.

First pull from the git repository – see Section 3.2 [Git cheat sheet], page 11, but **do not** rebase unless you are sure to master the translation state checking and updating system – then `cd` into `Documentation/` (or at top of the source tree, replace `make` with `make -C Documentation`) and run

```
make ISOLANG=MY-LANGUAGE check-translation
```

This presents a diff of the original files since the most recent revision of the translation and prints it to terminal output. Usually you'll want to pass this output to a terminal pager like `less` in order to scroll the diff up and down:

```
make ISOLANG=MY-LANGUAGE check-translation | less -R
```

To check a single file, `cd` into `Documentation/` and run

```
make TRANSLATION_FILES=MY-LANGUAGE/manual/foo.itely check-translation
```

In case this file has been renamed since you last updated the translation, you should specify both old and new file names, e.g., `TRANSLATION_FILES=MY-LANGUAGE/{manual,user}/foo.itely`.

To see only which files need to be updated, do

```
make ISOLANG=MY-LANGUAGE check-translation | grep -n 'diff --git'
```

The `-n` option of `grep` will print the line number of each occurrence, which can be used to estimate the length of each diff and the amount of work required.

To avoid printing terminal color control characters, which is often desirable when you redirect output to a file, run

```
make ISOLANG=MY-LANGUAGE NO_COLOR=1 check-translation
```

You can see the diffs generated by the commands above as changes that you should make in your language to the existing translation, in order to make your translation up to date.

> **Note:** do not forget to update the committish in each file you have completely updated, see [Updating translation committishes], page 59.

See also

[Maintaining without updating translations], page 60.

Updating documentation translation

Instead of running `check-translation`, you may want to execute `update-translation`, which will run your favorite text editor to update files. First, make sure the environment variable `EDITOR` is set to a text editor command, then run from `Documentation/`

```
make ISOLANG=MY-LANGUAGE update-translation
```

or, to update a single file,

```
make TRANSLATION_FILES=MY-LANGUAGE/manual/foo.itely update-translation
```

For each file to be updated, `update-translation` will open your text editor with this file and a diff of the file in English; if the diff cannot be generated or is bigger than the file in English itself, the full file in English will be opened instead.

> **Note:** do not forget to update the committish in each file you have completely updated, see [Updating translation committishes], page 59.

`.po` message catalogs in `Documentation/po/` may be updated by changing to either directory `Documentation/` or `Documentation/po/` and issuing

```
make po-update
```

However, this make target doesn't work properly right now.

> **Note:** if you run `po-update` and somebody else does the same and pushes before you push or send a patch to be applied to the git repository, there will be a conflict when you pull.

Updating music snippets can quickly become cumbersome, as most snippets should be identical in all languages. Fortunately, there is a script that can do this odd job for you (to be run from `Documentation/`):

```
make ISOLANG=MY-LANGUAGE snippet-update
```

This make target calls a script to overwrite music snippets in all `.itely` files in the *MY-LANGUAGE/* subdirectory with music snippets taken from the `en/` subdirectory. It ignores skeleton files and doesn't modify music snippets that are preceded by a line starting with `@c KEEP LY`. It reports an error for each `.itely` file that has not the same music snippet count in both languages. Always use this script with a lot of care, i.e., run it on a clean git working tree, and check the changes it made with `git diff` before committing! If you don't do so, some `@lilypond` snippets might be broken or make no sense in their context.

See also

[Maintaining without updating translations], page 60, Section 7.2 [Adding and editing snippets], page 64.

Updating translation committishes

At the beginning of each translated file (except for `.po` files), there is a *committish* (i.e., an SHA-1 tag consisting of 40 hexadecimal digits that uniquely identify a specific commit in a git repository) to represent the revision of the sources that you have used to translate this file from the file in English.

When you have pulled and updated a translation, it is very important to update this committish in the files you have completely updated (and only these); to do this, first commit possible changes to any documentation in English which you are sure to have done in your translation as well, then replace in the up-to-date translated files the old committish by the committish of the latest commit, which can be obtained by doing

```
git rev-list HEAD | head -1
```

Most of the changes in LilyPond Wiki snippets included in the documentation concern the syntax, not the description inside `texidoc="..."`. This implies that sometimes you will have to update only the committish of the matching `.texidoc` file and nothing else. It can be a tedious work if there are many snippets to be marked as up do date; you can use the following command to update the committishes at once:

```
cd Documentation/MY-LANGUAGE/texidocs
sed -i -r 's/[0-9a-z]{40}/NEW-COMMITTISH/' *.texidoc
```

See also

Chapter 7 [LilyPond Wiki work], page 64.

Maintaining without updating translations

Keeping translations up to date if the English documentation has been heavily changed is a hard task, especially when a lot of contributors submit changes.

It is possible – and even recommended – to perform some maintenance that keeps translated documentation usable and eases future translation updating.

The following tasks are listed in decreasing priority order; a rationale is given after the list.

1. Update `macros.itexi`. For each obsolete macro definition, if it is possible to update macro usage in documentation with an automatic text or regexp substitution, do it and delete the macro definition from `macros.itexi`; otherwise, mark this macro definition as obsolete with a comment, and keep it in `macros.itexi` until the documentation translation has been updated and no longer uses this macro.
2. Update `.tely` files completely with `make check-translation` – you may want to redirect output to a file because of overwhelming output, or directly call the `check-translation.py` script on individual files, see [Check state of translation], page 58.
3. In `.itely` files, match sections and `.itely` file names with those from the English documentation files, which possibly involves moving the contents of complete node blocks between files (without updating the documentation itself). In other words, the 'game' is to find out where each section has been moved to. In case there are completely new sections, copy `@node` and `@section` commands from the English documentation files and add the marker for untranslated status (`@untranslated`, on a line of its own). Note that it is often not possible to exactly match subsections or subsubsections of the English documentation when its contents has been deeply revised; in this case, keep obsolete (sub)subsections in the translation and mark them with a line `@c obsolete` just before the node.

   The Emacs editor with its Texinfo mode makes this step easier; here are some tips in case you are using it.

   - Without the AUCTeX package for Emacs installed, the key sequence `C-c C-s` shows the structure of the current Texinfo file in a new buffer called `*Occur*`. To show the structure of two files simultaneously, first split the Emacs window in 4 tiles (with `C-x 1` and `C-x 2`), then press `C-c C-s` to show the structure of one file (e.g., the translated file), copy the contents of `*Occur*` into the `*Scratch*` buffer, then press `C-c C-s` for the other file.

     If you happen to have AUCTeX installed, there is a function for this, which you can call with `M-x texinfo-show-structure`. You can also create a key binding in your `~/.emacs` configuration file by adding the four following lines:

     ```
     (add-hook 'Texinfo-mode-hook
               '(lambda ()
                  (define-key Texinfo-mode-map "\C-cs"
                   'texinfo-show-structure)))
     ```

     After restarting Emacs you can then obtain the structure in the `*Occur*` buffer with `C-c s`.

   - Moving to the next or previous node can be easily done with incremental search: press `C-s` and type `node` (or `C-s @node` if the text contains the word 'node'), then press `C-s` to move to the next node or `C-r` to move to the previous node. Similar operation can be used to move to the next or previous section. Note that every cursor move exits incremental search, and hitting `C-s` twice starts incremental search with the text entered in previous incremental search.

- Moving a whole node (or even a sequence of nodes): jump to beginning of the node (quit incremental search by pressing an arrow), press C-SPACE to set a mark, press C-s node and repeat C-s until you have selected enough text, cut it with C-w or C-x, jump to the right place (moving between nodes with the previous hint is often useful) and paste with C-y or C-v.

4. While working on Documentation/po/*MY-LANGUAGE*.po it is recommended not to update strings located in English documentation files that are actively revised. Instead, wait until the 'dust has settled' to avoid doing the work more than once.
5. Check and fix broken cross-references by changing to directory Documentation/ and running

   ```
   make ISOLANG=MY-LANGUAGE check-xrefs
   make ISOLANG=MY-LANGUAGE fix-xrefs
   ```

   This step requires a successful in-tree documentation build (with make doc). Some cross-references might be broken because they point to nodes that exist in the English documentation, and which have not been added to the translation. In this case, do not fix the cross-reference but keep it 'broken' so that the resulting HTML link will miss the exact spot in an existing page but still point to this page.

Rationale

You may wonder if it would not be better to leave translations as-is until you can really start updating translations. There are several reasons to do these maintenance tasks as soon as possible.

- The work must be done sooner or later anyway (before updating the translation of documentation contents), and in most cases it is not needed to repeat the process later since sections in the English documentation are mostly revised once. Of course, this might not be true sometimes, and then you really have to repeat the process.
- It makes the translation take advantage of the new documentation structure, which is better than staying with the old one.
- Moving and renaming sections to match the sectioning of English documentation simplifies future updating work: it allows updating the translation using a side-by-side comparison, without bothering whether cross-reference names already exist in the translation.
- Each maintenance task except 'Updating .po files' can be done by the same person for all languages, which saves overall time spent by translators to achieve this task: the node names are in English, so *you* can do it just fine.

5.9.4 Technical background

A number of Python scripts handle parts of the documentation translation process; they are located in the scripts/auxiliar/ directory.

- check_translation.py – show diff to update a translation,
- texi-langutils.py – parse Texinfo files to make message catalogs and extract Texinfo skeleton files,
- update-snippets.py – synchronize .ly snippets with those from the English documentation.

Python modules used by scripts in scripts/auxiliar/ or scripts/build/ (but not by installed Python scripts) are located in the python/auxiliar/ directory:

- buildlib.py – common functions (read piped output of a shell command, use git, etc.),
- postprocess_html.py (imported by www_post.py) – add footer and tweak links in HTML pages.

And finally there is

- python/langdefs.py – language definitions module.

6 Website work

6.1 Introduction to website work

The website is *not* written directly in HTML; instead it is autogenerated along with the documentation using Texinfo source files. Texinfo is the standard for documentation of GNU software and allows generating output in HTML, PDF, and Info formats, which drastically reduces maintenance effort and ensures that the website content is consistent with the rest of the documentation. This makes the environment for improving the website rather different from common web development.

If you have not contributed to LilyPond before, a good starting point might be incremental changes to the CSS file, to be found at `https://lilypond.org/css/lilypond-website.css` or in the LilyPond source code at `./Documentation/css/lilypond-website.css`.

Large scale structural changes tend to require familiarity with the project in general, a track record in working on LilyPond documentation as well as a prospect of long-term commitment.

The Texinfo source file for generating HTML are to be found in

```
Documentation/en/web.texi
Documentation/en/web/*.texi
```

Unless otherwise specified, follow the instructions and policies given in Chapter 5 [Documentation work], page 35. That chapter also contains a quick introduction to Texinfo; consulting an external Texinfo manual should be not necessary.

Exceptions to the documentation policies

- Sectioning: the website only uses chapters and sections; no subsections or subsubsections.
- @ref{}s to other manuals (@rnotation, @rlearning, etc): you can't link to any pieces of automatically generated documentation, like the IR or certain NR appendices.
- The bibliography in Community->Publications is generated automatically from `.bib` files; formatting is done automatically by `texi-web.bst`.
- ...
- For anything not listed here, just follow the same style as the existing website texinfo files.

6.2 Uploading website

Overall idea

The website is generated by converting the `Documentation/*/web.texi` files to HTML, and reorganizing the resulting files into `out/website-root/`. This is controlled from toplevel `GNUmakefile` and `Documentation/GNUmakefile`.

To build the website, run `make website`. This leaves the website in `out/website-root/`.

The website is deployed onto `lilypond.org` in the following steps:

- Run the manual job to build the website, either for the merge request you want to deploy or for the latest pipeline on `master` at `https://gitlab.com/lilypond/lilypond/-/pipelines`, by clicking the play button.
- This runs `make website` and stores the result in a `website.zip` artifact.
- On `lilypond.org`, the downloader `https://gitlab.com/lilypond/infrastructure/-/blob/master/website/main.go` is run every 2 hours, from a systemd timed job. If a newer `website.zip` is found, it is unpacked into the `website` directory on `lilypond.org`.

6.3 Debugging website and docs locally

- Install Apache (you can use version 2, but keep in mind that the server hosting lilypond.org runs version 1.3). These instructions assume that you also enable `mod_userdir`, and use `$HOME/public_html` as DocumentRoot (i.e., the root directory of the web server).
- Build the online docs and website:

  ```
  make WEB_TARGETS="offline online" doc
  make website
  ```

  This will make all the language variants of the website. To save a little time, just the English version can be made with the command `make WEB_LANGS='' website` or the English and (for example) the French with `make WEB_LANGS='fr' website`.
- Choose the web directory where to copy the built stuff. If you already have other web projects in your DocumentRoot and don't need to test the `.htaccess` file, you can copy to `~/public_html/lilypond.org`. Otherwise you'd better copy to `~/public_html`. It's highly recommended to have your build dir and web dir on the same partition.
- Add the directory for the online documentation:

  ```
  mkdir -p ~/public_html/doc/v2.19/
  ```

  You may want to add also the stable documentation in `~/public_html/doc/v2.18/`, extracting the contents of the html directory present in the tarball available in Section "All" in *General Information*. Just in case you want to test the redirects to the stable documentation.
- Copy the files with rsync:

  ```
  rsync -av --delete out-website/website ~/public_html/
  cp out-website/.htaccess ~/public_html
  rsync -av --delete out-www/online-root/ ~/public_html/doc/v2.19/
  ```

6.4 Translating the website

As it has much more audience, the website should be translated before the documentation; see Section 5.9 [Translating the documentation], page 53.

In addition to the normal documentation translation practices, there are a few additional things to note:

- Build the website with:

  ```
  make website
  ```
- Some of the translation infrastructure is defined in python files; you must look at the `### translation data` sections in:

  ```
  scripts/build/create-weblinks-itexi.py
  scripts/build/website_post.py
  ```

  Do not submit a patch to add your language to this file unless `make website` completes with fewer than 5 warnings.
- Links to manuals are done with macros like `@manualDevelLearningSplit`. To get translated links, you must change that to `@manualDevelLearningSplit-es` (for es/Spanish translations, for example).

7 LilyPond Wiki work

7.1 Introduction to the LilyPond Wiki

The LilyPond Wiki (`https://wiki.lilypond.community/`), which is the successor of the LilyPond Snippet Repository (LSR), has a large collection of LilyPond examples. A subset of these examples are automatically imported into the documentation, making it easy for users to contribute to the documentation without learning Git and Texinfo.

7.2 Adding and editing snippets

General guidelines

When you create (or find!) a nice snippet, please add it to the Wiki. Go to the LilyPond Wiki (`https://wiki.lilypond.community/`) and optionally log in – if you haven't already, create an account. Follow the help instructions on the website so that you know how to proceed.

You should always tag a newly created page with a category (`https://wiki.lilypond.community/wiki/Special:Categories`) at the end of a page. If you think a snippet is particularly informative and should be included in the documentation, suggest it in the snippet's 'Discussion' page. Note that snippets intended for the LilyPond documentation must have a special layout (`https://wiki.lilypond.community/wiki/Category:Included_in_the_official_documentation`).

Please make sure that the LilyPond code follows our formatting guidelines, see Section 5.4.5 [LilyPond formatting], page 39.

If a new snippet created for documentation purposes compiles with the current stable LilyPond version, it should be added to the Wiki. If a new snippet created for documentation purposes uses features that are not available in the current stable release of LilyPond, it should be put into directory `Documentation/snippets/new/` instead. In both cases, a reference to the snippet should be added to the documentation. Please ask a documentation editor to add a reference to it in an appropriate place in the docs. (Note – it should appear in the 'Snippets' manual automatically, once it has been imported into git and built. See Section 7.5 [LilyPond Wiki to Git], page 67.)

Snippets created or updated in `Documentation/snippets/new/` must be adjusted and copied to directory `Documentation/snippets/`. This should be done by invoking the `makelsr.pl` script – *after* you have compiled LilyPond. Assuming that your LilyPond build is in the top-level subdirectory `build/`, a proper invocation is

```
cd /your/lilypond/git/top/dir
scripts/auxiliar/makelsr.pl --new
```

See Section 7.4 [The `makelsr.pl` script], page 66, for more details.

Be sure that '`make doc`' runs successfully before submitting a patch, to prevent breaking compilation (see Section 4.6.2 [Generating documentation], page 29).

Formatting snippets in `Documentation/snippets/new/`

When adding a file to this directory, please use the following template (omitting the explanatory comments) ...

```
\version "2.xx.yy"

\header {
  % Use existing Wiki categories other than 'Category:Included in
  % the official documentation' and 'Category:Snippet' (see
```

```
  % 'https://wiki.lilypond.community/wiki/Special:Categories' for
  % a list) and omit the 'Category:' prefix.
  categories = "Rhythms, Expressive marks"

  % The documentation string must use Texinfo syntax.  In
  % addition, `\` and `"` must be written as `\\` and `\"`,
  % respectively.
  texidoc = "
This snippet demonstrates @code{\\foo} ...
"

  % The snippet title string must be formatted similar to
  % `texidoc`.  However, don't use markup commands like `@emph`
  % or `@code` so that the title can be directly converted to a
  % Wiki page title, which doesn't allow formatting.
  doctitle = "Snippet title"
}

<LilyPond code starts here>
```

... and name the file `snippet-title.ly`.

It is important that the version number you use at the top of the snippet is the minimum LilyPond version that the file compiles with; for example, if the snippet requires 2.25.24, use `\version "2.25.24"`.

Particular attention is also necessary for the `categories` and `doctitle` fields: the categories must match category names used in the Wiki (`https://wiki.lilypond.community/wiki/Special:Categories`), and the `doctitle` must match the file name (`makelsr.pl` shows a helpful error message if it doesn't).

The order of `\version`, `\header`, and the LilyPond code must be as shown above, otherwise `makelsr.pl` aborts with an error. The same holds for the order of the `categories`, `texidoc`, and `doctitle` fields within `\header`.

7.3 Snippet administration

Wiki administrators should shepherd users who create or modify snippets. An atom feed is available to track changes in the Wiki; see the 'about' info page (`https://wiki.lilypond.community/wiki/Meta:About`) for more.

Here is a checklist of the necessary tasks.

1. All snippets should have the 'Category:Snippet' category set.
2. Does the snippet make sense and does it actually do what the author claims that it does? If you think the snippet is suited to be included into the LilyPond documentation, add the 'Category:Included in the official documentation' category and at least one other category to classify it by topic.
3. If the snippet is tagged with the 'Category:Included in the official documentation' category, check whether the LilyPond source code matches our formatting guidelines, see Section 5.4.5 [LilyPond formatting], page 39.

   Also, snippets tagged with this category should not be explaining (or replicating) existing material in the documentation. They should not refer to the documentation either; the documentation should rather refer to them.
4. If the snippet uses Scheme code, check that everything looks good and that there are no security risks.

> **Note:** Somebody could add code like `#'(system "rm -rf /")` to a snippet, which would cause catastrophic results if executed! Take this step **VERY SERIOUSLY**.

7.4 The `makelsr.pl` script

As you might have guessed already, `makelsr.pl` is a Perl (`https://perl.org`) script. Obviously, you need Perl to execute it, which you should now install in case it isn't already available on your system.

There is a dependency on the `pandoc` program (`https://pandoc.org`). The script uses it to convert Wiki pages, which are formatted with MediaWiki Syntax (`https://www.mediawiki.org/wiki/Help:Formatting`), to the Texinfo format. This program must be installed, too.

Furthermore, `makelsr.pl` needs a few additional modules that are not Perl core modules:

- File::Which
- IPC::Run3
- Pandoc
- Parallel::ForkManager

Either install missing modules with your package manager (if available) or use the `cpanm` command.[1]

A typical call might me

```
cpanm --sudo Parallel::ForkManager
```

to download, compile, and install module 'Parallel::ForkManager'.[2]

The `--sudo` option makes the modules install into a system directory, for example `/usr/lib/perl5/site_perl/...` – you need the superuser password for this. If you don't want to do that for whatever reason, just omit `--sudo` and follow the instructions shown in `cpanm`'s error message to install Perl modules locally (i.e., without `sudo` rights).

Finally, it needs to find the `convert-ly` script from the current LilyPond development build.

By default, executing `makelsr.pl` performs the following actions.

- Download documentation snippets from the LilyPond Wiki.
- Delete all snippet and snippet list files in directory `Documentation/snippets/` (but not in `Documentation/snippets/new/`).
- Convert the snippets' documentation parts from MediaWiki syntax to Texinfo with the `pandoc` program, run the script `convert-ly` to update their LilyPond code parts to current syntax, and store them in `Documentation/snippets/`.
- Create snippet list files (with extension `.snippet-list`) that group snippets by Wiki categories. These files are used to structure LilyPond's 'Snippets' manual.
- Convert all snippet files in `Documentation/snippets/new/` with `convert-ly` and output them to `Documentation/snippets/`, possibly overwriting existing files.

This flow of actions can be adjusted; say '`scripts/auxiliar/makelsr.pl --help`' to get a detailed description of the provided command-line options and used environment variables.

---

[1] Most Perl distributions have this command included; if not, try to install a package named 'cpanminus' or having 'cpanminus' in its name.

[2] Note that the program `cpanm` might be called differently; it sometimes has the Perl version appended to its name, for example `cpanm-5.34`.

7.5 LilyPond Wiki to Git

Snippets used in the documentation are located in `$LILYPOND_GIT/Documentation/snippets/`. This directory contains a set of all snippets in the LilyPond Wiki that are tagged with the category 'Category:Included in the official documentation'. An import is done with the `makelsr.pl` script, which downloads all documentation snippets from the Wiki to update this directory.

Snippets that need a newer LilyPond version than the current stable release are located in directory `$LILYPOND_GIT/Documentation/snippets/new/`. Once LilyPond gets upgraded to the next stable version that can actually compile them, they are transferred to the Wiki and deleted from `snippets/new/`.

'Git' is the shorthand name for LilyPond's git repository, which contains all the development code. For further information on setting this up, see Chapter 3 [Working with source code], page 10. An alternative to setting up a git repository for people wanting to do LilyPond Wiki work is to get the source code from `https://lilypond.org/development.html`. However, we don't recommend this since it doesn't allow easy submission of patches as merge requests.

Importing the LilyPond Wiki into Git

1. Make sure that the `convert-ly` script is a bleeding edge version – the latest development release, or even better, freshly compiled from git master, with the environment variable `LILYPOND_BUILD_DIR` correctly set up (see Section 13.2 [Environment variables], page 121) in case your build directory isn't `$LILYPOND_GIT/build/`.
2. Check the other prerequisites necessary for executing the `makelsr.pl` script (see Section 7.4 [The makelsr.pl script], page 66).
3. If you are using a git repository, create and check out a branch, for example

   ```
   git checkout -b wiki-import
   ```

4. From the top source directory, execute

   ```
   scripts/auxiliar/makelsr.pl --diff-version-update
   ```

   Say '`scripts/auxiliar/makelsr.pl --help`' to find out how to modify this call; for example, command-line option `--dump` makes the script create a dump file of the Wiki that can be read in a later run with option `--input`.
5. Carefully check the output of the script for warnings and errors, then carefully check the file differences in the git repository. '`git diff`' is your friend.
6. Rebuild the documentation. If some snippets from `Documentation/snippets/` cause the documentation compilation to fail, try the following steps to fix it.
   - Look up the snippet file name *foo*`.ly` in the error output or log file, then fix the file `Documentation/snippets/`*foo*`.ly` to make the documentation build successfully.
   - Determine where the snippet comes from by looking at its first two lines, e.g., run

     ```
     head -2 Documentation/snippets/foo.ly
     ```

   - If the snippet comes from the LilyPond Wiki, also apply the fix to the snippet in the Wiki, see Section 7.2 [Adding and editing snippets], page 64.

     Note that the failure may sometimes not be caused by the snippet in the Wiki but by LilyPond syntax changes that `convert-ly` can't handle automatically. Such files *must* be added to the `new/` directory.
   - If the snippet comes from directory `Documentation/snippets/new/`, apply the fix in `Documentation/snippets/new/`*foo*`.ly` and run `makelsr.pl` as follows:

     ```
     scripts/auxiliar/makelsr.pl --new
     ```

     Then, inspect `Documentation/snippets/`*foo*`.ly` to check that the fix has been propagated correctly.

- If the build failure was caused by a translation string, you may have to fix some Documentation/*lang*/texidocs/*foo*.texidoc files instead.

7. When you are done, commit your changes to your git branch and create a merge request (see Section 3.3 [Lifecycle of a merge request], page 14).

Below is a simple shell script to process all .ly files in a directory sequentially (i.e., no support for parallel execution); this might help you find problems with snippets. If you pass option -s to the script, it runs silently except for reporting failed files. If run with option -c it also executes convert-ly prior to running lilypond. You need to set the LILYPOND_BUILD_DIR environment variable so that the two programs are found.

```
#!/bin/bash

while getopts sc opt; do
    case $opt in
        s) silent=true ;;
        c) convert=true ;;
    esac
done

param=$ if [ $silent ]; then
    param=${param:3}
fi
if [ $convert ]; then
    param=${param:3}
fi
filter=${param:-"*.ly"}

for LILYFILE in $filter; do
    STEM=$(basename "$LILYFILE" .ly)
    if [ $convert ]; then
        if [ $silent ]; then
            $LILYPOND_BUILD_DIR/out/bin/convert-ly \
-e "$LILYFILE" >& "$STEM".con.txt
        else
            $LILYPOND_BUILD_DIR/out/bin/convert-ly \
-e "$LILYFILE"
        fi
    fi
    if [ ! $silent ]; then
        echo "processing $LILYFILE..."
    fi
    $LILYPOND_BUILD_DIR/out/bin/lilypond \
--format=png "$LILYFILE" >& "$STEM".txt
    RetVal=$?
    if [ $RetVal -gt 0 ]; then
       echo "$LILYFILE failed"
    fi
done
```

This script stores logging output from lilypond and convert-ly in files *filename*.txt and *filename*.con.txt, respectively.

8 Issues

This chapter deals with defects, feature requests, and miscellaneous development tasks.

8.1 Introduction to issues

> **Note:** All the tasks in this chapter require no programming skills and can be done by anyone with a web browser, an email client and the ability to run LilyPond.

The term 'issues' refers not just to software bugs but also includes feature requests, documentation additions and corrections as well as any other general code 'TODOs' that need to be kept track of. Tasks revolving around issues include:

- Monitoring the LilyPond Bugs mailing list looking for any issues reported by other users ensuring that they are accurate and contain enough information for the developers to work with, preferably with Section "Tiny examples" in *General Information* and if applicable, screenshots.
- Adding new issues to the *issue tracker* or updating existing issues with new information.

To start working on bug triage, follow these steps:

1. Read every section of the Chapter 8 [Issues], page 69, chapter in this guide.
2. Subscribe your email account to `bug-lilypond`. See `https://lists.gnu.org/mailman/listinfo/bug-lilypond`.
3. Create your own GitLab login (required to manage issues):
   - Go to `https://gitlab.com/users/sign_in`.
   - Click on the 'Register' tab to create a new account.
   - Fill in your details as required and click the *Register* button to complete the registration.
4. Go to `https://gitlab.com/lilypond` and 'Request access' to the group. Additionally send your GitLab *username* (not your email address) to `bug-lilypond@gnu.org`, asking to be given appropriate permissions to manage issues.
5. Configure your email client to use some kind of sorting and filtering as this will significantly reduce and simplify your workload. Suggested email folder names are mentioned below to work when sorted alphabetically.

   Any email sent `To:` or `CC:` to `bug-lilypond` should be configured to go into a `bug-current` folder.

8.2 Triaging bugs

Emails to you personally

Sometimes a confused user will send a bug report (or an update to a report) to you personally. If that happens, please forward such emails to the `bug-lilypond` list.

Emails to `bug-answers`

Some of these emails will be comments on issues that you added to the tracker.

If they are asking for more information, give the additional information.

- If the email says that the issue was classified in some other manner, read the rationale given and take that into account for the next issue you add.
- Otherwise, move them to your `bug-ignore` folder.

Some of these emails will be discussions about Bug Squad work; read those.

Emails to `bug-current`

Dealing with these emails is your main task. Your job is to get rid of these emails in the first method which is applicable:

1. If the email has already been handled by a Bug Squad member (i.e. check to see who else has replied to it), delete it.
2. If the email is a question about how to use LilyPond, reply with this response:

   ```
   For questions about how to use LilyPond, please read our
   documentation available from:
     https://lilypond.org/manuals.html
   or ask the lilypond-user mailing list.
   ```

3. If the email mentions "the latest git", or any version number that has not yet been officially released, forward it to `lilypond-devel`.
4. If a bug report is not in the form of a Tiny example, direct the user to resubmit the report with this response:

   ```
   I'm sorry, but due to our limited resources for handling bugs, we
   can only accept reports in the form of Tiny examples.  Please see
   step 2 in our bug reporting guidelines:
     https://lilypond.org/bug-reports.html
   ```

5. If anything is unclear, ask the user for more information.

   How does the graphical output differ from what the user expected? What version of lilypond was used (if not given) and operating system (if this is a suspected cause of the problem)? In short, if you cannot understand what the problem is, ask the user to explain more. It is the user's responsibility to explain the problem, not your responsibility to understand it.
6. If the behavior is expected, the user should be told to read the documentation:

   ```
   I believe that this is the expected behavior -- please read our
   documentation about this topic.  If you think that it really is a
   mistake, please explain in more detail.  If you think that the
   docs are unclear, please suggest an improvement as described by
   "Simple tasks -- Documentation" on:
     https://lilypond.org/help-us.html
   ```

7. If the issue already exists in the tracker, send an email to that effect:

   ```
   This issue has already been reported; you can follow the
   discussion and be notified about fixes here:
   ```

   (copy+paste the GitLab issue URL)
8. Accept the report as described in Section 8.4 [Adding issues to the tracker], page 71.

All emails should be CC'd to the `bug-lilypond` list so that other Bug Squad members know that you have processed the email.

> **Note:** There is no option for "ignore the bug report" – if you cannot find a reason to reject the report, you must accept it.

8.3 Issue classification

We have several labels:

- Critical: normally a regression against the current stable version or the previous stable version. Alternatively, a regression against a fix developed for the current version. This does

not apply where the "regression" occurred because a feature was removed deliberately – this is not a bug.

Currently, only Critical items will block a stable release.

- Maintainability: hinders future development.
- Crash: any input which produces a crash.
- Ugly: overlapping or other ugly notation in graphical output.
- Defect: a problem in the core program. (the `lilypond` binary, scm files, fonts, etc).
- Documentation: inaccurate, missing, confusing, or desired additional info. Must be fixable by editing a texinfo, ly, or scm file.
- Build: problem or desired features in the build system. This includes the makefiles and python scripts.
- Scripts: problem or desired feature in the non-build-system scripts. Mostly used for convert-ly, lilypond-book, etc.
- Enhancement: a feature request for the core program. The distinction between enhancement and defect isn't extremely clear; when in doubt, mark it as enhancement.
- Other: anything else.
- Regression: it used to work intentionally in the current stable release or the previous stable release. If the earlier output was accidental (i.e., we didn't try to stop a collision, but it just so happened that two grobs didn't collide), then breaking it does not count as a regression.

  To help decide whether the change is a regression, please adopt the following process:

  1. Are you certain the change is OK? If so, do nothing.
  2. Are you certain that the change is bad? Add it to the tracker as a regression.
  3. If you're not certain either way, add it to the tracker as a regression but be aware that it may be recategorised or marked invalid.

  In particular, anything that breaks a regression test is a regression.
- Frog: the fix is believed to be suitable for a new contributor (does not require a great deal of knowledge about LilyPond). The issue should also have an estimated time in a comment.
- Bounty: somebody is willing to pay for the fix. Only add this tag if somebody has offered an exact figure in US dollars or euros.
- Warning: graphical output is fine, but lilypond prints a false/misleading warning message. Alternately, a warning should be printed (such as a bar line error), but was not. Also applies to warnings when compiling the source code or generating documentation.
- Performance: performance issue.

In addition, the following labels may be used when closing an issue:

- Invalid: issue should not have been added in the current state.
- Duplicate: issue already exists in the tracker.
- Shelved: issue won't fix and was abandoned.

Assign an issue to yourself to indicate that you are currently working on it.

8.4 Adding issues to the tracker

Note: This should only be done by the Bug Squad or experienced developers. Normal users should not do this; instead, they should follow the guidelines for Section "Bug reports" in *General Information*.

1. Check if the issue falls into any previous category given on the relevant checklists in Section 8.2 [Triaging bugs], page 69. If in doubt, add a new issue for a report. We would prefer to have some incorrectly-added issues rather than lose information that should have been added.
2. Add the issue and classify it according to the guidelines in Section 8.3 [Issue classification], page 70. In particular, the item should have `Status` and type labels.
3. Include output. Usually, the problem can be demonstrated in an image created using `lilypond -dcrop bug.ly`, which generates `bug.cropped.png`. However, for spacing bugs, this image may not show the problem; attach the full PDF produced by a normal `lilypond` invocation in this case.
4. After adding the issue, please send a response email to the same group(s) that the initial patch was sent to. If the initial email was sent to multiple mailing lists (such as both `user` and `bugs`), then reply to all those mailing lists as well. The email should contain a link to the issue you just added.

If patches are sent to the bug list, please submit them via GitLab (or help the author to do so). Alternatively, if discussion is needed, forward the patch to `lilypond-devel`.

9 Regression tests

9.1 Introduction to regression tests

LilyPond has a complete suite of regression tests that are used to ensure that changes to the code do not break existing behavior. These regression tests comprise small LilyPond snippets that test the functionality of each part of LilyPond.

Regression tests are added when new functionality is added to LilyPond or when bugs are fixed.

The regression tests are compiled using special `make` targets. There are three primary uses for the regression tests. First, successful completion of the regression tests means that LilyPond has been properly built. Second, the output of the regression tests can be manually checked to ensure that the graphical output matches the description of the intended output. Third, the regression test output from two different versions of LilyPond can be automatically compared to identify any differences. These differences should then be manually checked to ensure that the differences are intended.

Regression tests ("regtests") are available in precompiled form as part of the documentation. Regtests can also be compiled on any machine that has a properly configured LilyPond build system.

9.2 Precompiled regression tests

Regression test output

As part of the release process, the regression tests are run for every LilyPond release. Full regression test output is available for every stable version and the most recent development version.

Regression test output is available in HTML and PDF format. Links to the regression test output are available at the developer's resources page for the version of interest.

The latest stable version of the regtests is found at:

```
https://lilypond.org/doc/stable/input/regression/collated-files.html
```

The latest development version of the regtests is found at:

```
https://lilypond.org/doc/latest/input/regression/collated-files.html
```

9.3 Compiling regression tests

Developers may wish to see the output of the complete regression test suite for the current version of the source repository between releases. Current source code is available; see Chapter 3 [Working with source code], page 10.

For regression testing `../configure` should be run with the `--disable-optimising` option. Then you will need to build the LilyPond binary; see Section 4.5 [Compiling LilyPond], page 28.

Uninstalling the previous LilyPond version is not necessary, nor is running `make install`, since the tests will automatically be compiled with the LilyPond binary you have just built in your source directory.

From this point, the regtests are compiled with:

```
make test
```

If you have a multi-core machine you may want to use the `-j` option and *CPU_COUNT* variable, as described in [Saving time with CPU_COUNT], page 31. For a quad-core processor the complete command would be:

```
make -j5 CPU_COUNT=5 test
```

The regtest output will then be available in `input/regression/out-test`. `input/regression/out-test/collated-examples.html` contains a listing of all the regression tests that were run, but none of the images are included. Individual images are also available in this directory.

The primary use of '`make test`' is to verify that the regression tests all run without error. The regression test page that is part of the documentation is created only when the documentation is built, as described in Section 4.6.2 [Generating documentation], page 29. Note that building the documentation requires more installed components than building the source code, as described in Section 4.2.3 [Requirements for building documentation], page 24.

9.4 Regtest comparison

Before modified code is committed to `master`, a regression test comparison must be completed to ensure that the changes have not caused problems with previously working code. The comparison is made automatically upon compiling the regression test suite twice.

1. Before making changes to the code, establish a baseline for the comparison by checking out the current git master, going to the `$LILYPOND_GIT/build/` directory and running:

   ```
   make clean # whenever any files in mf/ are modified
   make test-baseline
   ```

2. Make your changes, or apply the patch(es) to consider.
3. Check for unintentional changes to the regtests:

   ```
   make check
   ```

   After this has finished, a regression test comparison will be available (relative to the current `build/` directory) at:

   ```
   out/test-results/index.html
   ```

   For each regression test that differs between the baseline and the changed code, a regression test entry will be displayed. Ideally, the only changes would be the changes that you were working on. If regressions are introduced, they must be fixed before committing the code.
4. If you are happy with the results, then skip to the final step.

   If you want to continue programming, then make any additional code changes, and continue.
5. Finally, you should verify that `make doc` completes successfully.

   Advanced note: Once a test baseline has been established, there is no need to run it again unless git master changed. In other words, if you work with several branches and want to do regtests comparison for all of them, you can `make test-baseline` with git master, checkout some branch, `make check` it, then switch to another branch, `make test-clean` and `make check` it without doing `make test-baseline` again.

9.5 Pixel-based regtest comparison

As an alternative to the `make test` method for regtest checking (which relies upon `.signature` files created by a LilyPond run and which describe the placing of grobs) there is a script which compares the output of two LilyPond versions pixel-by-pixel. To use this, start by checking out the version of LilyPond you want to use as a baseline, and run `make`. Then, do the following:

```
cd $LILYPOND_GIT/scripts/auxiliar/
./make-regtest-pngs.sh -j9 -o
```

The `-j9` option tells the script to use 9 CPUs to create the images - change this to your own CPU count+1. `-o` means this is the "old" version. This will create images of all the regtests in

```
$LILYPOND_BUILD_DIR/out-png-check/old-regtest-results/
```

Now checkout the version you want to compare with the baseline. Run `make` again to recreate the LilyPond binary. Then, do the following:

```
cd $LILYPOND_GIT/scripts/auxiliar/
./make-regtest-pngs.sh -j9 -n
```

The `-n` option tells the script to make a "new" version of the images. They are created in

```
$LILYPOND_BUILD_DIR/out-png-check/new-regtest-results/
```

Once the new images have been created, the script compares the old images with the new ones pixel-by-pixel and prints a list of the different images to the terminal, together with a count of how many differences were found. The results of the checks are in

```
$LILYPOND_BUILD_DIR/out-png-check/regtest-diffs/
```

To check for differences, browse that directory with an image viewer. Differences are shown in red. Be aware that some images with complex fonts or spacing annotations always display a few minor differences. These can safely be ignored.

9.6 Finding the cause of a regression

Git has special functionality to help tracking down the exact commit which causes a problem. See the git manual page for `git bisect`. This is a job that non-programmers can do, although it requires familiarity with git, ability to compile LilyPond, and generally a fair amount of technical knowledge. A brief summary is given below, but you may need to consult other documentation for in-depth explanations.

Even if you are not familiar with git or are not able to compile LilyPond you can still help to narrow down the cause of a regression simply by downloading the binary releases of different LilyPond versions and testing them for the regression. Knowing which version of LilyPond first exhibited the regression is helpful to a developer as it shortens the `git bisect` procedure.

Once a problematic commit is identified, the programmers' job is much easier. In fact, for most regression bugs, the majority of the time is spent simply finding the problematic commit.

More information is in Chapter 9 [Regression tests], page 73.

git bisect setup

We need to set up the bisect for each problem we want to investigate.

Suppose we have an input file which compiled in version 2.13.32, but fails in version 2.13.38 and above.

1. Begin the process:

   ```
   git bisect start
   ```

2. Give it the earliest known bad tag:

   ```
   git bisect bad release/2.13.38-1
   ```

   (you can see tags with: `git tag`)

3. Give it the latest known good tag:

   ```
   git bisect good release/2.13.32-1
   ```

   You should now see something like:

   ```
   Bisecting: 195 revisions left to test after this (roughly 8 steps)
   [b17e2f3d7a5853a30f7d5a3cdc6b5079e77a3d2a] Web: Announcement
   update for the new ‘‘LilyPond Report’’.
   ```

git bisect actual

1. Compile the source:

   ```
   make
   ```

2. Test your input file:

   ```
   out/bin/lilypond test.ly
   ```

3. Test results?
   - Does it crash, or is the output bad? If so:

     ```
     git bisect bad
     ```

   - Does your input file produce good output? If so:

     ```
     git bisect good
     ```

4. Once the exact problem commit has been identified, git will inform you with a message like:

   ```
   6d28aebbaaab1be9961a00bf15a1ef93acb91e30 is the first bad commit
   %%% ... blah blah blah ...
   ```

   If there is still a range of commits, then git will automatically select a new version for you to test. Go to step #1.

Recommendation: use two terminal windows

- One window is open to the `build/` directory, and alternates between these commands:

  ```
  make
  out/bin/lilypond test.ly
  ```

- One window is open to the top source directory, and alternates between these commands:

  ```
  git bisect good
  git bisect bad
  ```

9.7 MusicXML tests

LilyPond comes with a complete set of regtests for the MusicXML (`http://www.musicxml.org/`) language. Originally developed to test '`musicxml2ly`', these regression tests can be used to test any MusicXML implementation.

The MusicXML regression tests are found at `input/regression/musicxml/`.

The output resulting from running these tests through '`musicxml2ly`' followed by '`lilypond`' is available in the LilyPond documentation:

`https://lilypond.org/doc/latest/input/regression/musicxml/collated-files`

10 Programming work

10.1 Overview of LilyPond architecture

LilyPond processes the input file into graphical and musical output in a number of stages. This process, along with the types of routines that accomplish the various stages of the process, is described in this section. A more complete description of the LilyPond architecture and internal program execution is found in Erik Sandberg's master's thesis (`https://lilypond.gitlab.io/static-files/media/thesis-erik-sandberg.pdf`).

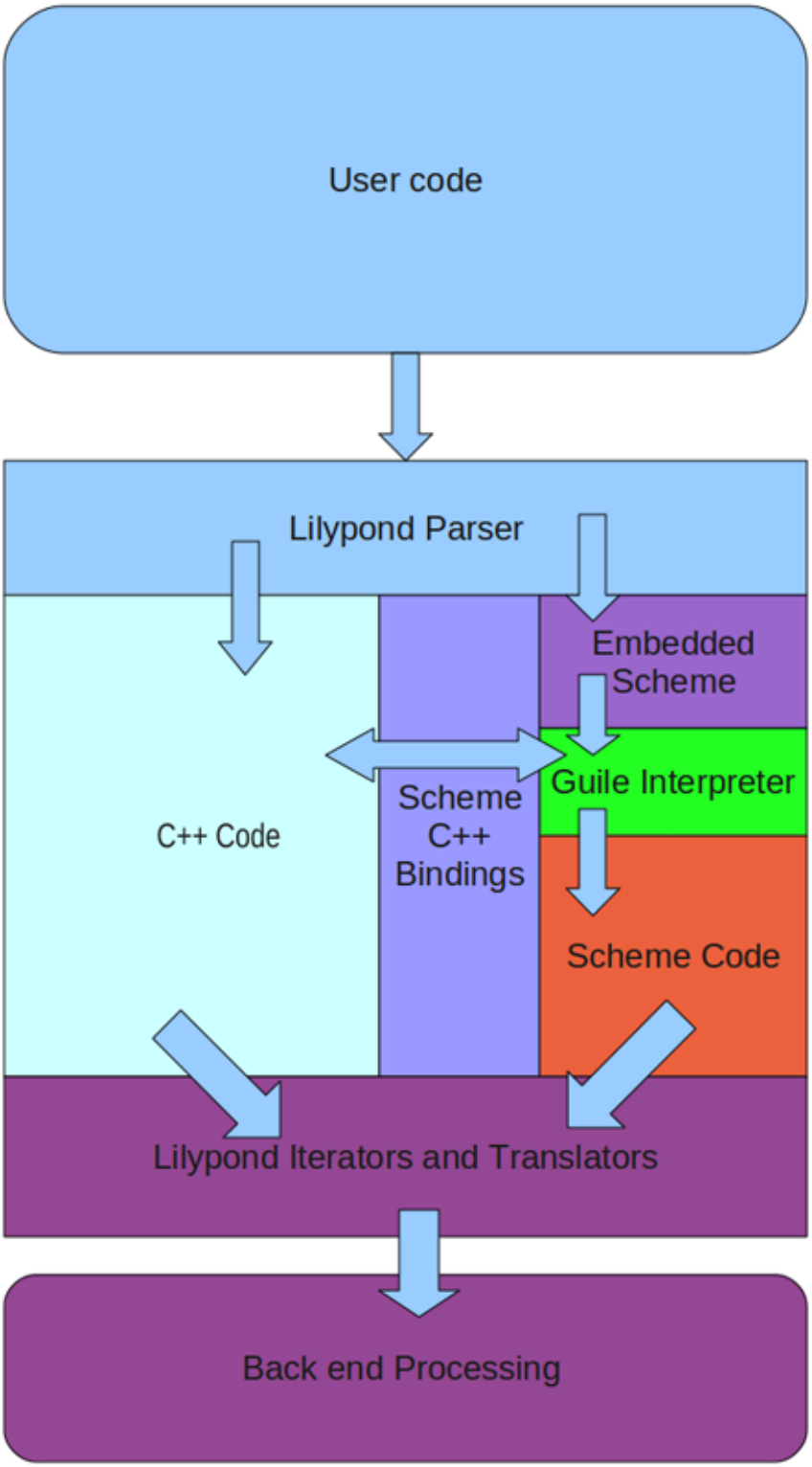
The first stage of LilyPond processing is *parsing*. In the parsing process, music expressions in LilyPond input format are converted to music expressions in Scheme format. In Scheme format, a music expression is a list in tree form, with nodes that indicate the relationships between various music events. The LilyPond parser is written in Bison.

The second stage of LilyPond processing is *iterating*. Iterating assigns each music event to a context, which is the environment in which the music will be finally engraved. The context is responsible for all further processing of the music. It is during the iteration stage that contexts are created as necessary to ensure that every note has a Voice type context (e.g. Voice, TabVoice, DrumVoice, CueVoice, MensuralVoice, VaticanaVoice, GregorianTranscriptionVoice), that the Voice type contexts exist in appropriate Staff type contexts, and that parallel Staff type contexts exist in StaffGroup type contexts. In addition, during the iteration stage each music event is assigned a moment, or a time in the music when the event begins.

Each type of music event has an associated iterator. Iterators are defined in `*-iterator.cc`. During iteration, an event's iterator is called to deliver that music event to the appropriate context(s).

The final stage of LilyPond processing is *translation*. During translation, music events are prepared for graphical or midi output. The translation step is accomplished by the polymorphic base class Translator through its two derived classes: Engraver (for graphical output) and Performer (for midi output).

Translators are defined in C++ files named `*-engraver.cc` and `*-performer.cc`. Much of the work of translating is handled by Scheme functions, which is one of the keys to LilyPond's exceptional flexibility.



10.2 LilyPond programming languages

Programming in LilyPond is done in a variety of programming languages. Each language is used for a specific purpose or purposes. This section describes the languages used and provides links to reference manuals and tutorials for the relevant language.

C++

The core functionality of LilyPond is implemented in C++.

C++ is so ubiquitous that it is difficult to identify either a reference manual or a tutorial. Programmers unfamiliar with C++ will need to spend some time to learn the language before attempting to modify the C++ code.

The C++ code calls Scheme/Guile through the Guile interface, which is documented in the Guile Reference Manual (`https://www.gnu.org/software/guile/manual/html_node/index.html`).

Flex

The LilyPond lexer is implemented in Flex, an implementation of the Unix lex lexical analyser generator. Resources for Flex can be found here (`http://flex.sourceforge.net/`).

GNU Bison

The LilyPond parser is implemented in Bison, a GNU parser generator. The Bison homepage is found at gnu.org (`https://www.gnu.org/software/bison/`). The manual (which includes both a reference and tutorial) is available (`https://www.gnu.org/software/bison/manual/index.html`) in a variety of formats.

GNU Make

GNU Make is used to control the compiling process and to build the documentation and the website. GNU Make documentation is available at the GNU website (`https://www.gnu.org/software/make/manual/`).

Guile or Scheme

Guile is the dialect of Scheme that is used as LilyPond's extension language. Many extensions to LilyPond are written entirely in Guile. The Guile Reference Manual (`https://www.gnu.org/software/guile/manual/html_node/index.html`) is available online.

Structure and Interpretation of Computer Programs (`https://mitpress.mit.edu/sicp/full-text/book/book.html`), a popular textbook used to teach programming in Scheme is available in its entirety online.

An introduction to Guile/Scheme as used in LilyPond can be found in the Section "Scheme tutorial" in *Extending*.

MetaFont

MetaFont is used to create the music fonts used by LilyPond. A MetaFont tutorial is available at the METAFONT tutorial page (`http://metafont.tutorial.free.fr/`).

PostScript

PostScript is used to generate graphical output. A brief PostScript tutorial is available online (`http://local.wasp.uwa.edu.au/~pbourke/dataformats/postscript/`). The PostScript Language Reference (`https://www.adobe.com/products/postscript/pdfs/PLRM.pdf`) is available online in PDF format.

Python

Python is used for XML2ly and is used for building the documentation and the website.

Python documentation is available at python.org (`https://www.python.org/doc/`).

Scalable Vector Graphics (SVG)

Scalable Vector Graphics (SVG) is an XML-based markup language used to generate graphical output. A brief SVG tutorial is available online (`https://www.w3schools.com/graphics/svg_intro.asp`) through W3 Schools. The World Wide Web Consortium's SVG 1.2 Recommendation (`https://www.w3.org/TR/SVG/REC-SVG11-20110816.pdf`) is available online in PDF format.

10.3 Programming without compiling

Much of the development work in LilyPond takes place by changing `*.ly` or `*.scm` files. These changes can be made without compiling LilyPond. Such changes are described in this section.

Modifying distribution files

Much of LilyPond is written in Scheme or LilyPond input files. These files are interpreted when the program is run, rather than being compiled when the program is built, and are present in all LilyPond distributions. You will find `.ly` files in the `ly/` directory and the Scheme files in the `scm/` directory. Both Scheme files and `.ly` files can be modified and saved with any text editor. It's probably wise to make a backup copy of your files before you modify them, although you can reinstall if the files become corrupted.

Once you've modified the files, you can test the changes just by running LilyPond on some input file. It's a good idea to create a file that demonstrates the feature you're trying to add. This file will eventually become a regression test and will be part of the LilyPond distribution.

Desired file formatting

Files that are part of the LilyPond distribution have Unix-style line endings (LF), rather than DOS (CR+LF) or Mac~OS~9 and earlier (CR). Make sure you use the necessary tools to ensure that Unix-style line endings are preserved in the patches you create.

Tab characters should not be included in files for distribution. All indentation should be done with spaces. Most editors have settings to allow the setting of tab stops and ensuring that no tab characters are included in the file.

Scheme files and LilyPond files should be written according to standard style guidelines. Scheme file guidelines can be found at `http://community.schemewiki.org/?scheme-style`. Following these guidelines will make your code easier to read. Both you and others that work on your code will be glad you followed these guidelines.

For LilyPond files, you should follow the guidelines for LilyPond snippets in the documentation. You can find these guidelines at Section 5.4 [Texinfo introduction and usage policy], page 37.

10.4 Finding functions

When making changes or fixing bugs in LilyPond, one of the initial challenges is finding out where in the code tree the functions to be modified live. With nearly 3000 files in the source tree, trial-and-error searching is generally ineffective. This section describes a process for finding interesting code.

Using the ROADMAP

The file ROADMAP is located in the main directory of the lilypond source. ROADMAP lists all of the directories in the LilyPond source tree, along with a brief description of the kind of files found in each directory. This can be a very helpful tool for deciding which directories to search when looking for a function.

Using grep to search

Having identified a likely subdirectory to search, the grep utility can be used to search for a function name. The format of the grep command is

```
grep -i functionName subdirectory/*
```

This command will search all the contents of the directory subdirectory/ and display every line in any of the files that contains functionName. The `-i` option makes `grep` ignore case – this can be very useful if you are not yet familiar with our capitalization conventions.

The most likely directories to grep for function names are `scm/` for scheme files, ly/ for lilypond input (`*.ly`) files, and `lily/` for C++ files.

Using git grep to search

If you have used git to obtain the source, you have access to a powerful tool to search for functions. The command:

```
git grep functionName
```

will search through all of the files that are present in the git repository looking for *functionName*. It also presents the results of the search using `less`, so the results are displayed one page at a time.

Using TAGS support

Many programs, including Emacs, ex, vi, and less, provide the ability to jump directly to the definition of an identifier based on precomputed cross-reference data. This data is usually contained in files named `TAGS`, for Emacs, or `tags`, for vi and other programs.

To generate these cross-reference data files the source code must be installed, but it is not necessary to compile LilyPond. Follow the instructions found in Section 4.3 [Getting the source code], page 25, through 'Checking build dependencies'. Once the `configure` command has run successfully, invoke the following command in the `build` directory.

```
make TAGS
```

This will create both `TAGS` and `tags` files in the source directory tree. To enable and use tags in a particular program, see the associated program documentation.

Searching on the git repository at GitLab and Savannah

GitLab's web interface provides a built-in search.

- Go to `https://gitlab.com/lilypond/lilypond/`
- Type *functionName* in the search box on the top, and hit enter/return

Alternatively you can also use the equivalent of git grep on the Savannah server.

- Go to `https://git.sv.gnu.org/gitweb/?p=lilypond.git`
- In the pulldown box that says commit, select grep.
- Type *functionName* in the search box, and hit enter/return

This will initiate a search of the remote git repository.

10.5 Code style

This section describes style guidelines for LilyPond source code.

10.5.1 Languages

C++ and Python are preferred. Python code should use PEP 8.

10.5.2 Filenames

Definitions of classes that are only accessed via pointers (*) or references (&) shall not be included as include files.

```
file names

     ".hh"   Include files
          ".cc"      Implementation files
          ".icc"     Inline definition files
          ".tcc"     non inline Template defs

in emacs:

          (setq auto-mode-alist
                (append '(("\\.make$" . makefile-mode)
                     ("\\.cc$" . c++-mode)
                     ("\\.icc$" . c++-mode)
                     ("\\.tcc$" . c++-mode)
                     ("\\.hh$" . c++-mode)
                     ("\\.pod$" . text-mode)
                     )
                   auto-mode-alist))
```

The class Class_name is coded in 'class-name.*'

10.5.3 Code formatting

Formatting tools

For C++ files, standard GNU coding style is used. You can reformat a file according to this style using the `clang-format` tool.

```
clang-format -i filename
```

The version of `clang-format` currently being used is version 21.1.

Bindings for `clang-format` are available for many editors, including Emacs and Vim.

`clang-format` can also be run on all files at once, but this is normally only done infrequently, more specifically before branching the next stable release.

```
clang-format -i $(git ls-files "*.cc" "*.hh" "*.icc" "*.tcc")
```

Similarly, we have a script that reformats Scheme files.

```
scripts/auxiliar/fixscm.sh filename
```

To run it on all files, use

```
scripts/auxiliar/fixscm.sh $(git ls-files "*.scm")
```

This script drives Emacs behind the scenes, so Emacs users will get the right behavior out-of-the-box.

For Python code, use `autopep8` with the following settings:

```
autopep8 -ia --ignore=E402 file.py
```

However, currently files under `release/binaries/` are formatted with a different tool, `black`.

Vim-specific configuration

For C++ formatting, although using a plugin that provides a binding for `clang-format` allows you to fix indentation automatically, it does not produce correct indentation as you type. You can, however, adjust your Vim configuration to come close. These settings were adapted from the

GNU GCC Wiki (https://gcc.gnu.org/wiki/FormattingCodeForGCC). Save the following in ~/.vim/after/ftplugin/cpp.vim:

```
setlocal cindent
setlocal cinoptions=>4,n-2,{2,^-2,:2,=2,g0,h2,p5,t0,+2,(0,u0,w1,m1
setlocal shiftwidth=2
setlocal softtabstop=2
setlocal textwidth=79
setlocal fo-=ro fo+=cql
" use spaces instead of tabs
setlocal expandtab
" remove trailing whitespace on write
autocmd BufWritePre * :%s/\s\+$//e
```

For Scheme code, you can use these settings in ~/.vim/after/syntax/scheme.vim:

```
" Additional Guile-specific 'forms'
syn keyword schemeSyntax define-public define*-public
syn keyword schemeSyntax define* lambda* let-keywords*
syn keyword schemeSyntax defmacro defmacro* define-macro
syn keyword schemeSyntax defmacro-public defmacro*-public
syn keyword schemeSyntax use-modules define-module
syn keyword schemeSyntax define-method define-class

" Additional LilyPond-specific 'forms'
syn keyword schemeSyntax define-markup-command define-markup-list-command
syn keyword schemeSyntax define-music-function def-grace-function

" All of the above should influence indenting too
setlocal lw+=define-public,define*-public
setlocal lw+=define*,lambda*,let-keywords*
setlocal lw+=defmacro,defmacro*,define-macro
setlocal lw+=defmacro-public,defmacro*-public
setlocal lw+=use-modules,define-module
setlocal lw+=define-method,define-class
setlocal lw+=define-markup-command,define-markup-list-command
setlocal lw+=define-music-function,def-grace-function

" These forms should not influence indenting
setlocal lw-=if
setlocal lw-=set!

" Try to highlight all ly: procedures
syn match schemeFunc "ly:[^) ]\+"
```

Files can be reindented automatically by highlighting the lines to be indented in visual mode (use *V* to enter visual mode) and pressing =, or a single line correctly indented in normal mode by pressing ==.

For documentation work on texinfo files, identify the file extensions used as texinfo files in your .vim/filetype.vim:

```
if exists("did_load_filetypes")
  finish
endif
augroup filetypedetect
```

```
    au! BufRead,BufNewFile *.itely setfiletype texinfo
    au! BufRead,BufNewFile *.itexi setfiletype texinfo
    au! BufRead,BufNewFile *.tely  setfiletype texinfo
  augroup END
```

and add these settings in `.vim/after/ftplugin/texinfo.vim`:

```
  setlocal expandtab
  setlocal shiftwidth=2
  setlocal textwidth=66
```

10.5.4 Naming Conventions

Naming conventions have been established for LilyPond source code.

Classes and Types

Classes begin with an uppercase letter, and words in class names are separated with _:

`This_is_a_class`

Members

Member variable names end with an underscore:

`Type Class::member_`

Macros

Macro names should be written in uppercase completely, with words separated by _:

`THIS_IS_A_MACRO`

Variables

Variable names should be complete words, rather than abbreviations. For example, it is preferred to use `thickness` rather than `th` or `t`.

Multi-word variable names in C++ should have the words separated by the underscore character ('_'):

`cxx_multiword_variable`

Multi-word variable names in Scheme should have the words separated by a hyphen ('-'):

`scheme-multiword-variable`

10.5.5 Broken code

Do not write broken code. This includes hardwired dependencies, hardwired constants, slow algorithms and obvious limitations. If you can not avoid it, mark the place clearly, and add a comment explaining shortcomings of the code.

Ideally, the comment marking the shortcoming would include TODO, so that it is marked for future fixing.

We reject broken-in-advance on principle.

10.5.6 Code comments

Comments may not be needed if descriptive variable names are used in the code and the logic is straightforward. However, if the logic is difficult to follow, and particularly if non-obvious code has been included to resolve a bug, a comment describing the logic and/or the need for the non-obvious code should be included.

There are instances where the current code could be commented better. If significant time is required to understand the code as part of preparing a patch, it would be wise to add comments reflecting your understanding to make future work easier.

10.5.7 Handling errors

As a general rule, you should always try to continue computations, even if there is some kind of error. When the program stops, it is often very hard for a user to pinpoint what part of the input causes an error. Finding the culprit is much easier if there is some viewable output.

So functions and methods do not return errorcodes, they never crash, but report a programming_error and try to carry on.

Error and warning messages need to be localized.

10.5.8 Localization

This document provides some guidelines to help programmers write proper user messages. To help translations, user messages must follow uniform conventions. Follow these rules when coding for LilyPond. Hopefully, this can be replaced by general GNU guidelines in the future. Even better would be to have an English (en_GB, en_US) guide helping programmers writing consistent messages for all GNU programs.

Non-preferred messages are marked with '+'. By convention, ungrammatical examples are marked with '*'. However, such ungrammatical examples may still be preferred.

- Every message to the user should be localized (and thus be marked for localization). This includes warning and error messages.
- Do not localize/gettextify:
  - `programming_error`
  - `programming_warning`
  - debug strings
  - output strings (PostScript, TeX, etc.)
- Messages to be localized must be encapsulated in `_ (`*`string`*`)` or `_f (`*`format`*`, ...)`, for example

  ```
  warning (_ ("need music in a score"));
  error (_f ("cannot open file: `%s'", file_name));
  ```

  In some rare cases you may need to call `gettext` by hand. This happens when you pre-define (a list of) string constants for later use. In that case, you'll probably also need to mark these string constants for translation, using `_i (`*`string`*`)`. The '_i' macro is a no-op, it only serves as a marker for `xgettext`.

  ```
  char const* messages[] = {
    _i ("enable debugging output"),
    _i ("ignore lilypond version"),
    0
  };

  void
  foo (int i)
  {
    puts (gettext (messages i));
  }
  ```

  See also `flower/getopt-long.cc` and `lily/main.cc`.
- Do not use leading or trailing whitespace in messages. If you need whitespace to be printed, prepend or append it to the translated message

  ```
  message ("Calculating line breaks..." + " ");
  ```

- Error or warning messages displayed with a file name and line number never start with a capital, eg,

  ```
  foo.ly: 12: not a duration: 3
  ```

  Messages containing a final verb, or a gerund ('-ing'-form) always start with a capital. Other (simpler) messages start with a lowercase letter

  ```
  Processing foo.ly...
  `foo': not declared.
  Not declaring: `foo'.
  ```

- Avoid abbreviations or short forms, use 'cannot' and 'do not' rather than 'can't' or 'don't' To avoid having a number of different messages for the same situation, we will use quoting like this `"message: `%s'"` for all strings. Numbers are not quoted:

  ```
  _f ("cannot open file: `%s'", name_str)
  _f ("cannot find character number: %d", i)
  ```

- Think about translation issues. In a lot of cases, it is better to translate a whole message. English grammar must not be imposed on the translator. So, instead of

  ```
  stem at  + moment.str () +  does not fit in beam
  ```

  have

  ```
  _f ("stem at %s does not fit in beam", moment.str ())
  ```

- Split up multi-sentence messages, whenever possible. Instead of

  ```
  warning (_f ("out of tune!  Can't find: `%s'", "Key_engraver"));
  warning (_f ("cannot find font `%s', loading default", font_name));
  ```

  rather say:

  ```
  warning (_ ("out of tune:"));
  warning (_f ("cannot find: `%s', "Key_engraver"));
  warning (_f ("cannot find font: `%s', font_name));
  warning (_f ("Loading default font"));
  ```

- If you must have multiple-sentence messages, use full punctuation. Use two spaces after end of sentence punctuation. No punctuation (esp. period) is used at the end of simple messages.

  ```
  _f ("Non-matching braces in text `%s', adding braces", text)
  _ ("Debug output disabled.  Compiled with NPRINT.")
  _f ("Huh?  Not a Request: `%s'.  Ignoring.", request)
  ```

- Do not modularize too much; words frequently cannot be translated without context. It is probably safe to treat most occurrences of words like stem, beam, crescendo as separately translatable words.

- When translating, it is preferable to put interesting information at the end of the message, rather than embedded in the middle. This especially applies to frequently used messages, even if this would mean sacrificing a bit of eloquence. This holds for original messages too, of course.

  ```
  en: cannot open: `foo.ly'
  +   nl: kan `foo.ly' niet openen (1)
  kan niet openen: `foo.ly'*   (2)
  niet te openen: `foo.ly'*    (3)
  ```

  The first nl message, although grammatically and stylistically correct, is not friendly for parsing by humans (even if they speak dutch). I guess we would prefer something like (2) or (3).

- Do not run make po/po-update with GNU gettext < 0.10.35

10.6 Warnings, Errors, Progress and Debug Output

Available log levels

LilyPond has several log levels to specify how verbose the output on the console should be, as shown in the following table. Note that only the first few characters of a given value are checked (as indicated); additionally, case doesn't matter. In other words, `ERR` is the same as `error` or `ERRO`, for example.

`NONE`	no output at all, even on failure
`ERR[OR]`	only error messages
`WARN`	only error messages and warnings
`BASIC`	warnings, errors, and basic progress (success, etc.)
`PROG[RESS]`	warnings, errors, and full progress messages
`INFO`	warnings, errors, progress, and more detailed information (default)
`DEBUG`	all messages, including full debug messages (very verbose!)

The log level can either be set with the environment variable `LILYPOND_LOGLEVEL` or on the command line with the `--loglevel=...` option.

Functions for debug and log output

LilyPond has two different types of error and log functions:

- If a warning or error is caused by an identified position in the input file, e.g., by a grob or by a music expression, the functions of the `Input` class provide logging functionality that prints the position of the message in addition to the message.
- If a message can not be associated with a particular position in an input file, e.g., the output file cannot be written, the functions in file `flower/include/warn.hh` provide logging functionality that only prints out the message, but no location.

There are also Scheme functions to access all of these logging functions from scheme. In addition, the `Grob` class contains some convenience wrappers for even easier access to these functions.

The message and debug functions in file `warn.hh` also have an optional argument `newline` to specify whether the message should always start on a new line or continue a previous message. They also do not have a particular input position associated, so there are no progress functions in the `Input` class. By default, function `progress_indication()` does *not* start on a new line but rather continues the previous output. All other functions by default start their output on a new line.

LilyPond's error functions come in three different flavors: fatal error messages, programming error messages, and normal error messages.

- Errors written by the `error()` function cause the `lilypond` binary to exit immediately, returning a non-zero value.
- Errors by `Input::error()` let `lilypond` continue the compilation but return a non-zero value (i.e., indicating an unsuccessful program execution).
- All other errors are printed on the console without making `lilypond` exit or indicate an unsuccessful return code; they only differ to warning messages by the displayed text and that they are shown with log level `ERROR`.

If the Scheme option `warning-as-error` is set, any warning is treated as if `Input::error()` was called.

All logging functions at a glance

	C++, no location	C++, from input location
ERROR	`error ()`, `programming_error (msg)`, `non_fatal_error (msg)`	`Input::error (msg)`, `Input::programming_error (msg)`
WARN	`warning (msg)`	`Input::warning (msg)`
BASIC	`basic_progress (msg)`	—
PROGRESS	`progress_indication (msg)`	—
INFO	`message (msg)`	`Input::message (msg)`
DEBUG	`debug_output (msg)`	`Input::debug_output (msg)`

	C++, from a Grob	Scheme, music expression
ERROR	`Grob::programming_error (msg)`	—
WARN	`Grob::warning (msg)`	`(ly:music-warning music msg)`
BASIC	—	—
PROGRESS	—	—
INFO	—	`(ly:music-message music msg)`
DEBUG	—	—

	Scheme, no location	Scheme, input location
ERROR	—	`(ly:error msg args)`, `(ly:programming-error msg args)`
WARN	`(ly:warning msg args)`	`(ly:input-warning input msg args)`
BASIC	`(ly:basic-progress msg args)`	—
PROGRESS	`(ly:progress msg args)`	—
INFO	`(ly:message msg args)`	`(ly:input-message input msg args)`
DEBUG	`(ly:debug msg args)`	—

10.7 Debugging LilyPond

The most commonly used tool for debugging LilyPond is the GNU debugger gdb. The gdb tool is used for investigating and debugging core LilyPond code written in C++. Another tool is available for debugging Scheme code using the Guile debugger. This section describes how to use both gdb and the Guile Debugger.

10.7.1 Debugging overview

Using a debugger simplifies troubleshooting in at least two ways.

First, breakpoints can be set to pause execution at any desired point. Then, when execution has paused, debugger commands can be issued to explore the values of various variables or to execute functions.

Second, the debugger can display a stack trace, which shows the sequence in which functions have been called and the arguments passed to the called functions.

10.7.2 Debugging C++ code

The GNU debugger, gdb, is the principal tool for debugging C++ code.

Compiling LilyPond for use with gdb

In order to use gdb with LilyPond, it is necessary to compile LilyPond with debugging information. This is the current default mode of compilation. Often debugging becomes more complicated

when the compiler has optimised variables and function calls away. In that case it may be helpful to run the following command in the main LilyPond source directory:

```
./configure --disable-optimising
make
```

This will create a version of LilyPond with minimal optimization which will allow the debugger to access all variables and step through the source code in-order. It may not accurately reproduce bugs encountered with the optimized version, however.

You should not do *make install* if you want to use a debugger with LilyPond. The *make install* command will strip debugging information from the LilyPond binary.

Typical gdb usage

Once you have compiled the LilyPond image with the necessary debugging information it will have been written to a location in a subfolder of your current working directory:

```
out/bin/lilypond
```

This is important as you will need to let gdb know where to find the image containing the symbol tables. You can invoke gdb from the command line using the following:

```
gdb out/bin/lilypond
```

This loads the LilyPond symbol tables into gdb. Then, to run LilyPond on `test.ly` under the debugger, enter the following:

```
run test.ly
```

at the gdb prompt.

As an alternative to running gdb at the command line you may try a graphical interface to gdb such as ddd:

```
ddd out/bin/lilypond
```

You can also use sets of standard gdb commands stored in a .gdbinit file (see next section).

Typical .gdbinit files

The behavior of gdb can be readily customized through the use of a *.gdbinit* file. A *.gdbinit* file is a file named *.gdbinit* (notice the "." at the beginning of the file name) that is placed in a user's home directory.

The *.gdbinit* file below is from Han-Wen. It sets breakpoints for all errors and defines functions for displaying scheme objects (ps), grobs (pgrob), and parsed music expressions (pmusic).

```
file $LILYPOND_GIT/build/out/bin/lilypond
b programming_error
b Grob::programming_error

define ps
   print ly_display_scm($arg0)
end
define pgrob
  print ly_display_scm($arg0->self_scm_)
  print ly_display_scm($arg0->mutable_property_alist_)
  print ly_display_scm($arg0->immutable_property_alist_)
  print ly_display_scm($arg0->object_alist_)
end
define pmusic
  print ly_display_scm($arg0->self_scm_)
  print ly_display_scm($arg0->mutable_property_alist_)
```

```
  print ly_display_scm($arg0->immutable_property_alist_)
end
```

10.7.3 Debugging Scheme code

Scheme code can be developed using the Guile command-line interpreter `top-repl`. You can either investigate interactively using just Guile or you can use the debugging tools available within Guile.

Using Guile interactively with LilyPond

In order to experiment with Scheme programming in the LilyPond environment, it is necessary to have a Guile interpreter that has all the LilyPond modules loaded. This requires the following steps.

First, define a Scheme symbol for the active module in the `.ly` file:

```
#(module-define! (resolve-module '(guile-user))
                 'lilypond-module (current-module))
```

Now place a Scheme function in the `.ly` file that gives an interactive Guile prompt:

```
#(top-repl)
```

When the `.ly` file is compiled, this causes the compilation to be interrupted and an interactive guile prompt to appear. Once the guile prompt appears, the LilyPond active module must be set as the current guile module:

```
guile> (set-current-module lilypond-module)
```

You can demonstrate these commands are operating properly by typing the name of a LilyPond public scheme function to check it has been defined:

```
guile> fret-diagram-verbose-markup
#<procedure fret-diagram-verbose-markup (layout props marking-list)>
```

If the LilyPond module has not been correctly loaded, an error message will be generated:

```
guile> fret-diagram-verbose-markup
ERROR: Unbound variable: fret-diagram-verbose-markup
ABORT: (unbound-variable)
```

Once the module is properly loaded, any valid LilyPond Scheme expression can be entered at the interactive prompt.

After the investigation is complete, the interactive guile interpreter can be exited:

```
guile> (quit)
```

The compilation of the `.ly` file will then continue.

Using the Guile debugger

To set breakpoints and/or enable tracing in Scheme functions, put

```
\include "guile-debugger.ly"
```

in your input file after any scheme procedures you have defined in that file. This will invoke the Guile command line after having set up the environment for the debug command line. When your input file is processed, a guile prompt will be displayed. You may now enter commands to set up breakpoints and enable tracing by the Guile debugger.

Using breakpoints

At the guile prompt, you can set breakpoints with the `set-break!` procedure:

```
guile> (set-break! my-scheme-procedure)
```

Once you have set the desired breakpoints, you exit the guile repl frame by typing:

```
guile> (quit)
```

Then, when one of the scheme routines for which you have set breakpoints is entered, guile will interrupt execution in a debug frame. At this point you will have access to Guile debugging commands. For a listing of these commands, type:

```
debug> help
```

Alternatively you may code the breakpoints in your LilyPond source file using a command such as:

```
#(set-break! my-scheme-procedure)
```

immediately after the `\include` statement. In this case the breakpoint will be set straight after you enter the `(quit)` command at the guile prompt.

Embedding breakpoint commands like this is particularly useful if you want to look at how the Scheme procedures in the `.scm` files supplied with LilyPond work. To do this, edit the file in the relevant directory to add this line near the top:

```
(use-modules (scm guile-debugger))
```

Now you can set a breakpoint after the procedure you are interested in has been declared. For example, if you are working on routines called by *print-book-with* in `lily-library.scm`:

```
(define (print-book-with book process-procedure)
  (let* ((paper (ly:parser-lookup '$defaultpaper))
         (layout (ly:parser-lookup '$defaultlayout))
         (outfile-name (get-outfile-name book)))
    (process-procedure book paper layout outfile-name)))

(define-public (print-book-with-defaults book)
  (print-book-with book ly:book-process))

(define-public (print-book-with-defaults-as-systems book)
  (print-book-with book ly:book-process-to-systems))
```

At this point in the code you could add this to set a breakpoint at print-book-with:

```
(set-break! print-book-with)
```

Tracing procedure calls and evaluator steps

Two forms of trace are available:

```
(set-trace-call! my-scheme-procedure)
```

and

```
(set-trace-subtree! my-scheme-procedure)
```

`set-trace-call!` causes Scheme to log a line to the standard output to show when the procedure is called and when it exits.

`set-trace-subtree!` traces every step the Scheme evaluator performs in evaluating the procedure.

10.7.4 Debugging scoring algorithms

Formatting of beams, slurs and ties is based on scoring. A large number of configurations is generated and each aesthetic aspect gets demerits. The best configuration (with least demerits) wins. By setting the following variables in a `\paper` or `\layout` block it is possible to gain some insight about the criteria that lead LilyPond to choose a particular configuration. The information is showed adjacent to the object in question.

`debug-beam-scoring`
: If set to `#t`, print demerits together with their cause, followed by the number of configurations that have been scored before concluding. Default: unset.

Example: 'L 18.95 C 655.12 c19/625' → demerits for stem lengths ('L') and collisions ('C'), scored 19 out of 625 initially considered configurations.

Possible demerit causes: collision ('C'), inappropriate stem length ('L'), beam direction different from damping direction ('Sd'), difference between beam slope and musical slope ('Sm'), deviation from ideal slope ('Si'), horizontal inter-quants ('H'), forbidden quants ('Fl'/'Fs').

Demerits are configurable, see Section "beam-interface" in *Internals Reference* for a list of tunable parameters.

`debug-slur-scoring`

If set to `#t`, print demerits together with their cause, followed by the sum of all demerits and the index of the slur configuration finally chosen. Default: unset.

Example: 'slope=2.00, R edge=10.51, variance=0.03 TOTAL=12.54 idx=4' → demerits for slope, distance of the right edge to the attachment point, variance of distance between note heads and slur. Total demerits: 12.54, index of the chosen configuration: 4.

Possible demerit causes: distance of the left/right slur edge to the attachment points ('L edge'/'R edge'), inappropriate slope ('slope'), distance variations between note heads and slur ('variance'), distances for heads that are between the slur and an imaginary line between the attachment points ('encompass'), too small distance between slur and tie extrema ('extra').

Demerits are configurable, see Section "slur-interface" in *Internals Reference* for a list of tunable parameters.

`debug-tie-scoring`

If set to `#t`, print the basic configuration of ties, followed by demerits and their corresponding causes and the total sum of demerits. Default: unset.

Example: '0 (0.23) u: vdist=1.08 lhdist=1.79 tie/stem dir=8.00 TOTAL=10.87' → offset from the center of the staff according tie specification: 0 staff-spaces, vertical distance of the tie's center in y-direction to the bottom (or top) of the tie: 0.23, direction: up. Demerits for vertical and horizontal distance to note head, same direction of stem and tie. Total demerits: 10.87.

Possible demerit causes: wrong tie direction ('wrong dir'), vertical distance to note heads ('vdist'), horizontal distance to left or right note head ('lhdist'/'rhdist'), same direction of stem and tie ('tie/stem dir'), position and direction of tie not matching, e.g., tie is in the upper half of the staff but has direction DOWN ('tie/pos dir'), tie is too short ('minlength'), tip of tie collides with staff line ('tipline'), collision with dot ('dot collision'), center of tie is too close to a staff line ('line center'), y-position (edge or center) of currently considered tie is less than the y-position of the previous tie ('monotone edge'/ 'monotone cent'), edge or center of tie is too close to the one considered previously ('tietie center'/'tietie edge'), unsymmetrical horizontal positioning with respect to the note heads ('length symm'), unsymmetrical vertical positioning with respect to the note heads ('pos symmetry').

Demerits are configurable, see Section "tie-interface" in *Internals Reference* for a list of tunable parameters.

10.7.5 Debugging skylines

To show the skylines used for spacing, use

```
\override SomeGrob.show-horizontal-skylines = ##t
```

or

```
\override SomeGrob.show-vertical-skylines = ##t
```

The option `debug-skylines` is equivalent to setting `show-vertical-skylines` on Section "VerticalAxisGroup" in *Internals Reference* and Section "System" in *Internals Reference*.

Another particularly useful application is showing the skylines used for note spacing:

```
\layout {
  \context {
    \Score
    \override PaperColumn.show-horizontal-skylines = ##t
    \override NonMusicalPaperColumn.show-horizontal-skylines = ##t
  }
}
```

This is also an occasion to test if the pure estimates used to build them are reasonably accurate.

10.8 Tracing object relationships

Understanding the LilyPond source often boils down to figuring out what is happening to the Grobs. Where (and why) are they being created, modified and destroyed? Tracing Lily through a debugger in order to identify these relationships can be time-consuming and tedious.

In order to simplify this process, a facility has been added to display the grobs that are created and the properties that are set and modified. Although it can be complex to get set up, once set up it easily provides detailed information about the life of grobs in the form of a network graph.

Each of the steps necessary to use the Graphviz utility is described below.

1. Install Graphviz

   In order to create the graph of the object relationships, it is first necessary to install Graphviz. Graphviz is available for a number of different platforms:

   ```
   https://www.graphviz.org/download/
   ```

2. Compile LilyPond with checking enabled

   In order for the Graphviz tool to work, LilyPond needs to be compiled with checking enabled. You can achieve this by configuring with

   ```
   ./configure --enable-checking
   ```

   The executable code of LilyPond must then be rebuilt from scratch:

   ```
   make clean && make
   ```

3. Create a Graphviz-compatible `.ly` file

   In order to use the Graphviz utility, the `.ly` file must include `ly/graphviz-init.ly`, and should then specify the grobs and symbols that should be tracked. An example of this is found in `input/regression/graphviz.ly`.

4. Run LilyPond with output sent to a log file

   The Graphviz data can be sent to an arbitrary output port, including files, standard output or standard error. In the example given in `input/regression/graphviz.ly`, the graph is sent to stderr, like normal progress messages. You can redirect it to a logfile:

   ```
   lilypond graphviz.ly 2> graphviz.log
   ```

   In this case, you have to delete everything from the beginning of the file up to but not including the first occurrence of `digraph`. Also, delete the final LilyPond message about success from the end of the file.

   Alternatively, you can change the output port to stdout. See `input/regression/graphviz.ly` for a commented example. Then you get only the graph with the following invocation:

   ```
   lilypond graphviz.ly 1> graphviz.dot
   ```

5. Process the logfile with `dot`

   The directed graph is created from the log file with the program `dot`:

   ```
   dot -Tpdf graphviz.dot > graphviz.pdf
   ```

   The pdf file can then be viewed with any pdf viewer.

6. Interpret the created graph

   Depending on the callbacks that were specified to be tracked within the Graphviz framework, the graph does contain varying information. It is possible to track grob creation, modification of grob properties and caching of grob properties. Generally, all tracked events happening to a particular grob are presented as a directed graph, with arrows connecting the events. All property modifications that occur within a specific file in the source code are grouped by a blue border. Caching a grob property means to calculate the result of a callback function once and store the result afterwards for further use. The node labels can be configured freely. To understand which information is showed by default, see `ly/graphviz-init.ly`.

When configured with `--enable-checking`, LilyPond may run slower than normal. The original configuration can be restored by rerunning `./configure` with `--disable-checking`. Then rebuild LilyPond with

```
make clean && make
```

10.9 Tracing processing time

The `-dtime-trace-file` option causes LilyPond to log its internal processing in Google's Trace Event Format, also known as Chrome tracing format. The resulting JSON file can be displayed as a timeline chart using a viewer such as `https://ui.perfetto.dev/`.

The time-trace log includes many significant events during initialization, parsing, and output. Other events may be added following existing uses of `tracer_global`.

10.10 Adding or modifying features

When a new feature is to be added to LilyPond, it is necessary to ensure that the feature is properly integrated to maintain its long-term support. This section describes the steps necessary for feature addition and modification.

10.10.1 Write the code

You should probably create a new git branch for writing the code, as that will separate it from the master branch and allow you to continue to work on small projects related to master.

Please be sure to follow the rules for programming style discussed earlier in this chapter.

10.10.2 Write regression tests

In order to demonstrate that the code works properly, you will need to write one or more regression tests. These tests are typically `.ly` files that are found in `input/regression`.

Regression tests should be as brief as possible to demonstrate the functionality of the code.

Regression tests should generally cover one issue per test. Several short, single-issue regression tests are preferred to a single, long, multiple-issue regression test.

If the change in the output is small or easy to overlook, use bigger staff size – 40 or more (up to 100 in extreme cases). Size 30 means "pay extra attention to details in general".

Use existing regression tests as templates to demonstrate the type of header information that should be included in a regression test.

10.10.3 Write convert-ly rule

If the modification changes the input syntax, a convert-ly rule should be written to automatically update input files from older versions.

convert-ly rules are found in python/convertrules.py

If possible, the convert-ly rule should allow automatic updating of the file. In some cases, this will not be possible, so the rule will simply point out to the user that the feature needs manual correction.

10.10.4 Automatically update documentation

`convert-ly` should be used to update the documentation, the snippets, and the regression tests. This not only makes the necessary syntax changes, it also tests the `convert-ly` rules.

The automatic updating is performed by changing to the top-level source directory, then running:

```
scripts/auxiliar/update-with-convert-ly.sh
```

If you did an out-of-tree build, pass in the relative path:

```
LILYPOND_BUILD_DIR=../build-lilypond/ \
  scripts/auxiliar/update-with-convert-ly.sh
```

10.10.5 Manually update documentation

Where the `convert-ly` rule is not able to automatically update the inline LilyPond code in the documentation (i.e., if a `NOT_SMART` rule is used), the documentation must be manually updated. The inline snippets that require modification must be changed in the English version of the documentation and all translated versions. If the inline code is not changed in the translated documentation, old snippets will show up instead.

Where the `convert-ly` rule is not able to automatically update snippets in `Documentation/snippets/`, those snippets must be manually updated and copied to `Documentation/snippets/new`. The comments at the top of the snippet describing its automatic generation should be removed. All translated texidoc strings should be removed. The comment '`% begin verbatim`' should be removed. The syntax of the snippet should then be manually edited.

Where snippets in `Documentation/snippets` are made obsolete, the snippet should be copied to `Documentation/snippets/new`. The comments and texidoc strings should be removed as described above. Then the body of the snippet should be changed to:

```
\markup {
  This snippet is deprecated as of version X.Y.Z and
  will be removed from the documentation.
}
```

where 'X.Y.Z' is the version number for which the `convert-ly` rule was written.

Update the snippet files by running:

```
scripts/auxiliar/makelsr.pl --no-lsr --no-snippet-list
```

Where the `convert-ly` rule is not able to automatically update regression tests, the regression tests in `input/regression/` should be manually edited.

Although it is not required, it is helpful if the developer can write relevant material for inclusion in the Notation Reference. If the developer does not feel qualified to write the documentation, a documentation editor will be able to write it from the regression tests. In this case the developer should raise a new issue in the tracker (setting the 'Doc' label) containing a reference to the original issue number and/or the committish of the pushed patch so that the need for new documention is not overlooked.

Any text that is added to or removed from the documentation should be changed only in the English version.

10.10.6 Edit changes.tely

An entry should be added to Documentation/changes.tely to describe the feature changes to be implemented. This is especially important for changes that change input file syntax.

Hints for changes.tely entries are given at the top of the file.

New entries in changes.tely go at the top of the file.

The changes.tely entry should be written to show how the new change improves LilyPond, if possible.

10.10.7 Verify successful build

When the changes have been made, successful completion must be verified by doing

```
make all
make doc
```

When these commands complete without error, the patch is considered to function successfully.

Developers on Windows who are unable to build LilyPond should get help from a GNU/Linux or OSX developer to do the make tests.

10.10.8 Verify regression tests

In order to avoid breaking LilyPond, it is important to verify that the regression tests succeed, and that no unwanted changes are introduced into the output. This process is described in Section 9.4 [Regtest comparison], page 74.

Typical developer's edit/compile/test cycle

- Initial test:

```
make clean                      ## when needed (see below)
make [-jX CPU_COUNT=X] test-baseline
```

- Edit/compile/test cycle:

```
## edit source files, then...

make clean                      ## when needed (see below)
make [-jX]                      ## when needed (see below)
make [-jX CPU_COUNT=X] check    ## retest cases differing from baseline
```

- Reset:

```
make test-clean
```

If you have modified LilyPond source files that have to be compiled (such as `.cc` or `.hh` files in `flower/` or `lily/`), the regression-test targets automatically rebuild LilyPond before running the tests.

If you have modified any font definitions in the `mf/` directory, then you must run `make clean` before running regression tests. This works around incomplete makefile dependencies. The subsequent regression-test target rebuilds all of LilyPond and the fonts before running the tests.

Regression-test targets do not necessarily rebuild everything that a simple `make` builds. You may omit `make` from the debugging cycle to save time, but it is still important to run `make` before committing.

Running `make check` leaves an HTML page `out/test-results/index.html`. This page shows all the important differences that your change introduced, whether in the layout, MIDI, performance or error reporting.

You only need to use `make test-clean` to retest all cases. To retest mismatching cases only, all that is needed is to repeat `make check`.

10.10.9 Post patch for comments

See Section 3.3.1 [Uploading a patch for review], page 14.

10.10.10 Push patch

Once all the comments have been addressed, the patch can be pushed.

If the author has push privileges, the author will push the patch. Otherwise, a developer with push privileges will push the patch.

10.10.11 Closing the issues

Once the patch has been pushed, all the relevant issues should be closed.

If the changes were in response to a feature request on the issue tracker for LilyPond, the author should change the label to 'Status::Fixed' and set the milestone to the version where the issue was fixed.

10.11 Iterator tutorial

TODO – this is a placeholder for a tutorial on iterators

Iterators are routines written in C++ that process music expressions and sent the music events to the appropriate engravers and/or performers.

See a short example discussing iterators and their duties in Section 10.19.4 [Articulations on EventChord], page 113.

10.12 Engraver tutorial

Engravers are C++ classes that catch music events and create the appropriate grobs for display on the page. Though the majority of engravers are responsible for the creation of a single grob, in some cases (e.g. `New_fingering_engraver`), several different grobs may be created.

Engravers listen for events and acknowledge grobs. Events are passed to the engraver in time-step order during the iteration phase. Grobs are made available to the engraver when they are created by other engravers during the iteration phase.

10.12.1 Useful methods for information processing

An engraver inherits the following public methods from the Translator base class, which can be used to process listened events and acknowledged grobs:

- `virtual void initialize ()`
- `void start_translation_timestep ()`
- `void process_music ()`
- `void process_acknowledged ()`
- `void stop_translation_timestep ()`
- `virtual void finalize ()`

These methods are listed in order of translation time, with `initialize ()` and `finalize ()` bookending the whole process. `initialize ()` can be used for one-time initialization of context properties before translation starts, whereas `finalize ()` is often used to tie up loose ends at the end of translation: for example, an unterminated spanner might be completed automatically or reported with a warning message.

In addition, there is a `derived_mark` method that should be used to protect Scheme members from garbage collection. See Section 10.18 [Garbage collection for dummies], page 104.

10.12.2 Translation process

At each timestep in the music, translation proceeds by calling the following methods in turn:

`start_translation_timestep ()` is called before any user information enters the translators, i.e., no property operations (\set, \override, etc.) or events have been processed yet.

`process_music ()` and `process_acknowledged ()` are called after all events in the current time step have been heard, or all grobs in the current time step have been acknowledged. The latter tends to be used exclusively with engravers which only acknowledge grobs, whereas the former is the default method for main processing within engravers.

`stop_translation_timestep ()` is called after all user information has been processed prior to beginning the translation for the next timestep.

10.12.3 Listening to music events

External interfaces to the engraver are implemented by protected macros including one or more of the following:

- `DECLARE_TRANSLATOR_LISTENER (event_name)`
- `IMPLEMENT_TRANSLATOR_LISTENER (Engraver_name, event_name)`

where *event_name* is the type of event required to provide the input the engraver needs and *Engraver_name* is the name of the engraver.

Following declaration of a listener, the method is implemented as follows:

```
IMPLEMENT_TRANSLATOR_LISTENER (Engraver_name, event_name)
void
Engraver_name::listen_event_name (Stream event *event)
{
  ...body of listener method...
}
```

10.12.4 Acknowledging grobs

Some engravers also need information from grobs as they are created and as they terminate. The mechanism and methods to obtain this information are set up by the macros:

- `DECLARE_ACKNOWLEDGER (grob_interface)`
- `DECLARE_END_ACKNOWLEDGER (grob_interface)`

where *grob_interface* is an interface supported by the grob(s) which should be acknowledged. For example, the following code would declare acknowledgers for a `NoteHead` grob (via the `note-head-interface`) and any grobs which support the `side-position-interface`:

```
DECLARE_ACKNOWLEDGER (note_head)
DECLARE_ACKNOWLEDGER (side_position)
```

The `DECLARE_END_ACKNOWLEDGER ()` macro sets up a spanner-specific acknowledger which will be called whenever a spanner ends.

Following declaration of an acknowledger, the method is coded as follows:

```
void
Engraver_name::acknowledge_interface_name (Grob_info info)
{
  ...body of acknowledger method...
}
```

Acknowledge functions are called in the order engravers are `\consist`-ed (the only exception is if you set `must-be-last` to `#t`).

There will always be a call to `process-acknowledged ()` whenever grobs have been created, and *reading* stuff from grobs should be delayed until then since other acknowledgers might *write* stuff into a grob even after your acknowledger has been called. So the basic workflow is to use the various acknowledgers to *record* the grobs you are interested in and *write* stuff into them (or do read/write stuff that more or less is accumulative and/or really unrelated to other engravers), and then use the `process-acknowledged ()` hook for processing (including *reading*) the grobs you had recorded.

You can create new grobs in `process-acknowledged ()`. That will lead to a new cycle of `acknowledger ()` calls followed by a new cycle of `process-acknowledged ()` calls.

Only when all those cycles are over is `stop-translator-timestep ()` called, and then creating grobs is no longer an option. You can still 'process' parts of the grob there (if that means just reading out properties and possibly setting context properties based on them) but `stop-translation-timestep ()` is a cleanup hook, and other engravers might have already cleaned up stuff you might have wanted to use. Creating grobs in there is not possible since engravers and other code may no longer be in a state where they could process them, possibly causing a crash.

10.12.5 Engraver declaration/documentation

An engraver must have a public macro

- `TRANSLATOR_DECLARATIONS (Engraver_name)`

where `Engraver_name` is the name of the engraver. This defines the common variables and methods used by every engraver.

At the end of the engraver file, one or both of the following macros are generally called to document the engraver in the Internals Reference:

- `ADD_ACKNOWLEDGER (Engraver_name, grob_interface)`
- `ADD_TRANSLATOR (Engraver_name, Engraver_doc, Engraver_creates, Engraver_reads, Engraver_writes)`

where `Engraver_name` is the name of the engraver, `grob_interface` is the name of the interface that will be acknowledged, `Engraver_doc` is a docstring for the engraver, `Engraver_creates` is the set of grobs created by the engraver, `Engraver_reads` is the set of properties read by the engraver, and `Engraver_writes` is the set of properties written by the engraver.

The `ADD_ACKNOWLEDGER` and `ADD_TRANSLATOR` macros use a non-standard indentation system. Each interface, grob, read property, and write property is on its own line, and the closing parenthesis and semicolon for the macro all occupy a separate line beneath the final interface or write property. See existing engraver files for more information.

10.13 Callback tutorial

TODO – This is a placeholder for a tutorial on callback functions.

10.14 Understanding pure properties

Pure properties are some of the most difficult properties to understand in LilyPond but, once understood, it is much easier to work with horizontal spacing. This document provides an overview of what it means for something to be 'pure' in LilyPond, what this purity guarantees, and where pure properties are stored and used. It finishes by discussing a few case studies for the pure programmer to save you some time and to prevent you some major headaches.

10.14.1 Purity in LilyPond

Pure properties in LilyPond are properties that do not have any 'side effects'. That is, looking up a pure property should never result in calls to the following functions:

- `set_property`
- `set_object`
- `suicide`

This means that, if the property is calculated via a callback, this callback must not only avoid the functions above but make sure that any functions it calls also avoid the functions above. Also, to date in LilyPond, a pure function will always return the same value before line breaking (or, more precisely, before any version of `break_into_pieces` is called). This convention makes it possible to cache pure functions and be more flexible about the order in which functions are called. For example; `Stem.length` has a pure property that will *never* trigger one of the functions listed above and will *always* return the same value before line breaking, independent of where it is called. Sometimes, this will be the actual length of the Stem. But sometimes it will not. For example; stem that links up with a beam will need its end set to the Y position of the beam at the stem's X position. However, the beam's Y positions can only be known after the score is broken up in to several systems (a beam that has a shallow slope on a compressed line of music, for example, may have a steeper one on an uncompressed line). Thus, we only call the impure version of the properties once we are *absolutely certain* that all of the parameters needed to calculate their final value have been calculated. The pure version provides a useful estimate of what this Stem length (or any property) will be, and the art of creating good pure properties is trying to get the estimation as close to the actual value as possible.

Of course, like Gregory Peck and Tintin, some Grobs will have properties that will always be pure. For example, the height of a note-head in not-crazy music will never depend on line breaking or other parameters decided late in the typesetting process. Inversely, in rare cases, certain properties are difficult to estimate with pure values. For example, the height of a Hairpin at a certain cross-section of its horizontal span is difficult to know without knowing the horizontal distance that the hairpin spans, and LilyPond provides an over-estimation by reporting the pure height as the entire height of the Hairpin.

Purity, like for those living in a convent, is more like a contract than an *a priori*. If you write a pure-function, you are promising the user (and the developer who may have to clean up after you) that your function will not be dependent on factors that change at different stages of the compilation process (compilation of a score, not of LilyPond).

One last oddity is that purity, in LilyPond, is currently limited exclusively to things that have to do with Y-extent and positioning. There is no concept of 'pure X' as, by design, X is always the independent variable (i.e., from column X1 to column X2, what will be the Y height of a given grob). Furthermore, there is no purity for properties like color, text, and other things for which a meaningful notion of estimation is either not necessary or has not yet been found. For example, even if a color were susceptible to change at different points of the compilation process, it is not clear what a pure estimate of this color would be or how this pure color could be used. Thus, in this document and in the source, you will see purity discussed almost interchangeably with Y-axis positioning issues.

10.14.2 Writing a pure function

Pure functions take, at a minimum, three arguments: the *grob*, the starting column at which the function is being evaluated (hereafter referred to as *start*), and the end column at which the grob is being evaluated (hereafter referred to as *end*). For items, *start* and *end* must be provided (meaning they are not optional) but will not have a meaningful impact on the result, as items only occupy one column and will thus yield a value or not (if they are not in the range from *start* to *end*). For spanners however, *start* and *end* are important, as we may can get a better

pure estimation of a slice of the spanner than considering it on the whole. This is useful during line breaking, for example, when we want to estimate the Y-extent of a spanner broken at given starting and ending columns.

10.14.3 How purity is defined and stored

Purity is defined in LilyPond with the creation of an unpure-pure container (unpure is not a word, but hey, neither was LilyPond until the 90s). For example:

```
#(define (foo grob)
  '(-1 . 1))

#(define (bar grob start end)
  '(-2 . 2))

\override Stem.length = #(ly:make-unpure-pure-container foo bar)
```

Note that items can only ever have two pure heights: their actual pure height if they are between 'start' and 'end', or an empty interval if they are not. Thus, their pure property is cached to speed LilyPond up. Pure heights for spanners are generally not cached as they change depending on the start and end values. They are only cached in certain particular cases. Before writing a lot of caching code, make sure that it is a value that will be reused a lot.

10.14.4 Where purity is used

Pure Y values must be used in any functions that are called before line breaking. Examples of this can be seen in `Separation_items::boxes` to construct horizontal skylines and in `Note_spacing::stem_dir_correction` to correct for optical illusions in spacing. Pure properties are also used in the calculation of other pure properties. For example, the `Axis_group_interface` has pure functions that look up other pure functions.

Purity is also implicitly used in any functions that should only ever return pure values. For example, extra-spacing-height is only ever used before line-breaking and thus should never use values that would only be available after line breaking. In this case, there is no need to create callbacks with pure equivalents because these functions, by design, need to be pure.

To know if a property will be called before and/or after line-breaking is sometimes tricky and can, like all things in coding, be found by using a debugger and/or adding *printf* statements to see where they are called in various circumstances.

10.14.5 Case studies

In each of these case studies, we expose a problem in pure properties, a solution, and the pros and cons of this solution.

Time signatures

A time signature needs to prevent accidentals from passing over or under it, but its extent does not necessarily extend to the Y-position of accidentals. LilyPond's horizontal spacing sometimes makes a line of music compact and, when doing so, allows certain columns to pass over each other if they will not collide. This type of passing over is not desirable with time signatures in traditional engraving. But how do we know if this passing over will happen before line breaking, as we are not sure what the X positions will be? We need a pure estimation of how much extra spacing height the time signatures would need to prevent this form of passing over without making this height so large as to overly-distort the Y-extent of an system, which could result in a very 'loose' looking score with lots of horizontal space between columns. So, to approximate this extra spacing height, we use the Y-extent of a time signature's next-door-neighbor grobs via the pure-from-neighbor interface.

- pros: By extending the extra spacing height of a time signature to that of its next-door-neighbors, we make sure that grobs to the right of it that could pass above or below it do not.
- cons: This over-estimation of the vertical height could prevent snug vertical spacing of systems, as the system will be registered as being taller at the point of the time signature than it actually is. This approach can be used for clefs and bar lines as well.

Stems

As described above, Stems need pure height approximations when they are beamed, as we do not know the beam positions before line breaking. To estimate this pure height, we take all the stems in a beam and find their pure heights as if they were not beamed. Then, we find the union of all these pure heights and take the intersection between this interval (which is large) and an interval going from the note-head of a stem to infinity in the direction of the stem so that the interval stops at the note head.

- pros: This is guaranteed to be at least as long as the beamed stem, as a beamed stem will never go over the ideal length of the extremal beam of a stem.
- cons: Certain stems will be estimated as being too long, which leads to the same problem of too-much-vertical-height as described above.

10.14.6 Debugging tips

A few questions to ask yourself when working with pure properties:

- Is the property really pure? Are you sure that its value could not be changed later in the compiling process due to other changes?
- Can the property be made to correspond even more exactly with the eventual impure property?
- For a spanner, is the pure property changing correctly depending on the starting and ending points of the spanner?
- For an Item, will the item's pure height need to act in horizontal spacing but not in vertical spacing? If so, use extra-spacing-height instead of pure height.

10.15 LilyPond scoping

The LilyPond language has a concept of scoping, i.e., you can do:

```
foo = 1

#(begin
   (display (+ foo 2)))
```

with `\paper`, `\midi` and `\header` being nested scope inside the `.ly` file-level scope. `foo = 1` is translated in to a scheme variable definition.

This implemented using modules, with each scope being an anonymous module that imports its enclosing scope's module.

LilyPond's core, loaded from `.scm` files, is usually placed in the `lily` module, outside the `.ly` level. In the case of

```
lilypond a.ly b.ly
```

we want to reuse the built-in definitions, without changes effected in user-level `a.ly` leaking into the processing of `b.ly`.

The user-accessible definition commands have to take care to avoid memory leaks that could occur when running multiple files. All information belonging to user-defined commands and markups is stored in a manner that allows it to be garbage-collected when the module is dispersed, either by being stored module-locally, or in weak hash tables.

10.16 Regular expressions

Never use Guile's native regular expressions in LilyPond. They are a source of portability problems, especially in relation with Unicode. Instead, use LilyPond's own regular expression interface, which is made of all `ly:regex-...` functions (see the Internals Reference).

10.17 Scheme->C interface

Most of the C functions interfacing with Guile/Scheme used in LilyPond are described in the API Reference of the Guile Reference Manual (`https://www.gnu.org/software/guile/manual/html_node/index.html`).

The remaining functions are defined in `lily/lily-guile.cc`, `lily/include/lily-guile.hh` and `lily/include/lily-guile-macros.hh`. Although their names are meaningful there's a few things you should know about them.

10.17.1 Comparison

This is the trickiest part of the interface.

Mixing Scheme values with C comparison operators won't produce any crash or warning when compiling but must be avoided:

```
scm_string_p (scm_value) == SCM_BOOL_T
```

As we can read in the reference, `scm_string_p` returns a Scheme value: either `#t` or `#f` which are written `SCM_BOOL_T` and `SCM_BOOL_F` in C. This will work, but it is not following to the API guidelines. For further information, read this discussion:

```
https://lists.gnu.org/archive/html/lilypond-devel/2011-08/msg00646.html
```

There are functions in the Guile reference that returns C values instead of Scheme values. In our example, a function called `scm_is_string` (described after `string?` and `scm_string_p`) returns the C value 0 or 1.

So the best solution was simply:

```
scm_is_string (scm_value)
```

There a simple solution for almost every common comparison. Another example: we want to know if a Scheme value is a non-empty list. Instead of:

```
(scm_is_true (scm_list_p (scm_value)) && scm_value != SCM_EOL)
```

one can usually use:

```
scm_is_pair (scm_value)
```

since a list of at least one member is a pair. This test is cheap; `scm_list_p` is actually quite more complex since it makes sure that its argument is neither a 'dotted list' where the last pair has a non-null `cdr`, nor a circular list. There are few situations where the complexity of those tests make sense.

Unfortunately, there is not a `scm_is_[something]` function for everything. That's one of the reasons why LilyPond has its own Scheme interface. As a rule of thumb, tests that are cheap enough to be worth inlining tend to have such a C interface. So there is `scm_is_pair` but not `scm_is_list`, and `scm_is_eq` but not `scm_is_equal`.

General definitions

bool to_boolean (SCM b)

Return `true` if *b* is `SCM_BOOL_T`, else return `false`.

This should be used instead of `scm_is_true` and `scm_is_false` for properties since in LilyPond, unset properties are read as an empty list, and by convention unset Boolean properties

default to false. Since both `scm_is_true` and `scm_is_false` only compare with `##f` in line with what Scheme's conditionals do, they are not really useful for checking the state of a Boolean property.

bool ly_is_[something] (args)

Behave the same as scm_is_[something] would do if it existed.

bool is_[type] (SCM s)

Test whether the type of *s* is [type]. [type] is a LilyPond-only set of values (direction, axis...). More often than not, the code checks LilyPond specific C++-implemented types using

[Type *] unsmob<Type> (SCM s)

This tries converting a Scheme object to a pointer of the desired kind. If the Scheme object is of the wrong type, a pointer value of `0` is returned, making this suitable for a Boolean test.

10.17.2 Conversion

General definitions

bool to_boolean (SCM b)

Return `true` if *b* is `SCM_BOOL_T`, else return `false`.

This should be used instead of `scm_is_true` and `scm_is_false` for properties since empty lists are sometimes used to unset them.

[C type] ly_scm2[C type] (SCM s)

Behave the same as scm_to_[C type] would do if it existed.

[C type] robust_scm2[C type] (SCM s, [C type] d)

Behave the same as scm_to_[C type] would do if it existed. Return *d* if type verification fails.

10.18 Garbage collection for dummies

> **Note:** Reading this section is strongly recommended before attempting complex C++ programming.

Within LilyPond, interaction with Guile is ubiquitous. LilyPond is written in C++ and Guile Scheme. Even in C++, most of the code uses Guile APIs to interface with the outside Scheme world, both with user and internal Scheme code.

Scheme is a garbage-collected language. This means that once in a while, a so-called garbage collector scans the memory for values that are no longer being used, and reclaims them. This process ensures that the memory is given back to the computer and made available for other uses. The garbage collector implementation used in Guile 2 and later is the Boehm-Demers-Weiser garbage collector (BDWGC).

C++, on the other hand, usually frees values at determined points of time (although most of the time they remain implicit, through the use of the famous "RAII" or "scope-bound resource management" technique). It has no direct support for garbage collection. This can make memory management of Scheme values in C++ a challenge (or a headache). Whenever you are using a value whose memory is managed by Guile, you **must** keep an eye on its lifetime.

To be more precise, the garbage collector works in a *mark* phase and a *sweep* phase. During marking, the collector scans values that the program is currently using, then asks these values

for containing references to other values, and continues following references until all reachable objects have been found. Objects that are unreachable can logically no longer be used in the program, so they are freed in the sweep phase.

In Schemeland, the interpreter takes care of marking values for you. For instance, if you store a list in a variable, then during garbage collection, this list is automatically marked, and this causes all elements of the list to be marked in turn, which ensures they remain alive. In Cppland, you need to be very careful to keep values allocated on Guile's heap as visible to the garbage collector if they cannot be reached from the Scheme side.

Understanding which values are under garbage-collected management

To begin with, which values are allocated on the Guile heap? The basic Guile API type is the SCM type, which represents a value boxed for usage in Scheme. The SCM type is pointer-sized piece of data. It is either a pointer to Scheme data structures (e.g. pair, double pair, etc.) – in this case, the pointer is 64-bit aligned and has its lower bits set to 0 –, or it is an immediate value (short integer, boolean, `'()`, etc.) – in which case the lower order bits are non-zero. Smobs, vectors, strings and many other Scheme data structures are represented as pairs, where the car holds a tag value (non-aligned, lower order bits set) and the cdr holds the pointer to data. From the scheme side, the fact that these types are represented using pairs is invisible.

Thus, for immediate SCM values, all the value is contained in the SCM itself. There is no concept of freeing these values, as they are never heap-allocated: they just keep being copied around, and dropped by normal C++ lifetime mechanisms when done (such as dropping local variables of a function when it returns). On the other hand, all other values point to memory allocated on the Guile heap. It is the lifetime of this memory that you need to care about.

LilyPond adds its own object types to Guile as well. They as called "smobs", which depending on sources means "Scheme objects" or "small objects". Smobs come in two flavors:

"Simple smobs" are objects that can be passed around by copy without changing the meaning. Their classes derive from `Simple_smob`. `Pitch` and `Duration` are good examples. The usual way to create them is just like a normal C++ object (e.g., `Smob_type variable (constructor parameters);`). When created in this way, simple smobs are allocated on the stack like any other C++ automatic variable, and dropped in the same way too. When you need to send a simple smob to Schemeland, you should call the member function `smobbed_copy ()`. This calls the smob's copy constructor to make a copy under garbage collection control, packed in an SCM value.

"Complex smobs" are objects with an identity, such as `Music`, `Context` and `Grob`. Their classes derive from `Smob`. They are always created via the C++ `new` operator. After allocating, their memory is put under the control of the garbage collector. A complex smob has a field containing its SCM identity, which points back to itself. You can access this field using the member function `self_scm ()`.

The function to convert a SCM value back into the C++ smob type is `unsmob<Smob_type *> (value)` (which returns a null pointer if the SCM was not a value of the smob type in question). Because of the dual nature of simple smobs, you need to be mindful that if `Smob_type` derives from `Simple_smob`, the memory referred to by the result of `unsmob<Smob_type>` (if non-null) may either be on the stack or on the Guile heap, even though most of the time it will be on the Guile heap. On the other hand, for a complex smob, it will systematically be on the Guile heap.

How values are protected

When the garbage collector starts a collection, it first scans all memory being used by the program at the current point of time. This is called the root set. For Scheme, it includes all global variables of all modules and local variables of the function being executed. C++ adds everything that is on the stack and in registers (FIXME: investigate global variables). The dependencies of these values are then marked, etc.

Marking roots

The marking of the C++ function stack is very simple: scan the stack and treat every value as a possible pointer. This principle is called "conservative garbage collection", and has a few consequences. One is that there may be some false positives, if random values on the stack happen to look the same as pointers to memory in the Guile heap. These values will be held longer than necessary, which is harmless.

Another, much more nasty consequence is that values are *only* kept alive while they have an SCM presence on the stack. Here is an example of what *not* to do:

```
Complex_smob_type *
func ()
{
  Complex_smob_type *object = new Complex_smob_type ();
  object->unprotect ();
  return object;
}
```

When the caller of this function receives the object pointer, there is no reason for the object's SCM identity (what would be returned by its `self_scm ()` method) to be present on the stack or in registers. Only the pointer to the C++ object is. This does not work to protect the object from garbage collection. The object could be freed if a GC pass occurs. The fix is to unprotect later if possible, at a point where the object's `self_scm ()` is placed in a long-lived reachable Scheme data structure. Alternatively, if this is impractical, return an SCM to keep the object protected. The `unprotect ()` method actually returns the SCM for convenience.

```
SCM
func ()
{
  Complex_smob_type *object = new Complex_smob_type ();
  return object->unprotect ();
}
```

A different, even nastier trap can be illustrated with this example:

```
LY_DEFINE (ly_func, "ly:func",
           1, 0, 0, (SCM param),
           R"(
Doc
           )")
{
  Smob_type *object = unsmob<Smob_type> (param);
  // do some stuff here, including
  scm_cons (a, b)
  // ...
  return to_scm (object->some_field_);
}
```

At first glance, this looks fine. The SCM value `param` should remain on the stack until the end of the function, keeping the smob protected. This is not always true, however. If the compiler does a clever optimization, it might reuse the memory of the `param` variable for something else. If this happens, the object is unprotected while the memory of the cons cell is being allocated, which could cause the smob to be collected. The access `object->some_field_` is then use-after-free.

The solution to this is to use `scm_remember_upto_here`, which allows to forcefully keep the object alive:

```
LY_DEFINE (ly_func, "ly:func",
```

```
            1, 0, 0, (SCM param),
            R"(
Doc
            )")
{
  Smob_type *object = unsmob<Smob_type> (param);
  // do some stuff here, including
  scm_cons (a, b)
  // ...
  SCM field = to_scm (object->some_field_);
  scm_remember_upto_here (param);
  return field;
}
```

GC marking for smobs

Guile automatically marks the elements contained in compound values of the types it provides, like lists and vectors. LilyPond's smobs must do the same in order to keep elements they refer to alive while they are themselves alive. This is done by implementing the member function `SCM mark_smob () const`. This function must call `scm_gc_mark` on every Scheme value that needs to be kept alive with the object. It can return an SCM value, which is marked in the same way. (This dates back to Guile 1, which used the C++ function stack to mark objects. It was necessary to keep the stack depth constant when marking objects such as lists, or stack overflows would have easily ensued. It is no longer very relevant in Guile 2.)

For many smob types, `mark_smob` needs to add marking to the implementation of the superclass. This is usually done using a `derived_mark` method. This is the case for translators, for example. The child class should thus just implement `derived_mark` and not override `mark_smob`.

For simple smobs allocated as automatic variables, i.e., outside of Guile's control, `mark_smob` is *not* called during garbage collection. In this case, the only marking that the object receives is conservative scanning of the stack. This has the strong implication that a simple smob must contain all SCM values it refers to in its memory image on the stack. Anything that needs more complex marking behavior should be a complex smob. For example, it's not OK for a simple smob to contain an `std::vector<SCM>`. On the other hand, that would be OK for a complex smob as long as its `mark_smob` function iterates over the vector to mark each element. The simplest solution is storing a Guile vector, of SCM type, which *is* OK even in simple smobs because the memory image on the stack is an SCM vector value, which during marking causes the marking of all vector elements, unlike an `std::vector<SCM>`.

Initial protection for complex smobs

When you create a complex smob, it receives an initial GC protection, which should be removed with its `unprotect ()` method once the complex smob enters an area where it is protected by other means.

There is no such protection for a `smobbed_copy ()` of a simple smob because those tend to be more short-lived and are often just returned to Scheme after being created.

TODO: expand on smob constructors, especially the need for Preinit classes. See `lily/include/smobs.hh`.

TODO: explain the quirks of finalization (non-)ordering. See commit `6555b3841a`.

10.19 LilyPond miscellany

This is a place to dump information that may be of use to developers but doesn't yet have a proper home. Ideally, the length of this section would become zero as items are moved to other homes.

10.19.1 Spacing algorithms

Here is information from an email exchange about spacing algorithms.

On Thu, 2010-02-04 at 15:33 -0500, Boris Shingarov wrote: I am experimenting with some modifications to the line breaking code, and I am stuck trying to understand how some of it works. So far my understanding is that Simple_spacer operates on a vector of Grobs, and it is a well-known Constrained-QP problem (rods = constraints, springs = quadratic function to minimize). What I don't understand is, if the spacer operates at the level of Grobs, which are built at an earlier stage in the pipeline, how are the changes necessitated by differences in line breaking, taken into account? in other words, if I take the last measure of a line and place it on the next line, it is not just a matter of literally moving that graphic to where the start of the next line is, but I also need to draw a clef, key signature, and possibly other fundamental things – but at that stage in the rendering pipeline, is it not too late??

Joe Neeman answered:

We create lots of extra grobs (e.g., a BarNumber at every bar line) but most of them are not drawn. See the break-visibility property in item-interface.

Here is another e-mail exchange. Janek Warchoł asked for a starting point to fixing 1301 (change clef colliding with notes). Neil Puttock replied:

The clef is on a loose column (it floats before the head), so the first place I'd look would be lily/spacing-loose-columns.cc (and possibly lily/spacing-determine-loose-columns.cc). I'd guess the problem is the way loose columns are spaced between other columns: in this snippet, the columns for the quaver and tuplet minim are so close together that the clef's column gets dumped on top of the quaver (since it's loose, it doesn't influence the spacing).

10.19.2 Info from Han-Wen email

In 2004, Douglas Linhardt decided to try starting a document that would explain LilyPond architecture and design principles. The material below is extracted from that email, which can be found at `http://thread.gmane.org/gmane.comp.gnu.lilypond.devel/2992`. The headings reflect questions from Doug or comments from Han-Wen; the body text are Han-Wen's answers.

Figuring out how things work.

I must admit that when I want to know how a program works, I use grep and emacs and dive into the source code. The comments and the code itself are usually more revealing than technical documents.

What's a grob, and how is one used?

Graphical object - they are created from within engravers, either as Spanners (derived class) -slurs, beams- or Items (also a derived class) -notes, clefs, etc.

There are two other derived classes System (derived from Spanner, containing a "line of music") and Paper_column (derived from Item, it contains all items that happen at the same moment). They are separate classes because they play a special role in the linebreaking process.

What's a smob, and how is one used?

A C(++) object that is encapsulated so it can be used as a Scheme object. See Guile info, "19.3 Defining New Types (Smobs)"

When is each C++ class constructed and used?

- Music classes

  In the parser.yy see the macro calls MAKE_MUSIC_BY_NAME().

- Contexts

  Constructed during "interpreting" phase.

- Engravers

  Executive branch of Contexts, plugins that create grobs, usually one engraver per grob type. Created together with context.

- Layout Objects

  = grobs

- Grob Interfaces

  These are not C++ classes per se. The idea of a Grob interface hasn't crystallized well. ATM, an interface is a symbol, with a bunch of grob properties. They are not objects that are created or destroyed.

- Iterators

  Objects that walk through different music classes, and deliver events in a synchronized way, so that notes that play together are processed at the same moment and (as a result) end up on the same horizontal position.

  Created during interpreting phase.

  BTW, the entry point for interpreting is ly:run-translator (ly_run_translator on the C++ side)

Can you get to Context properties from a Music object?

You can create music object with a Scheme function that reads context properties (the \apply-context syntax). However, that function is executed during Interpreting, so you can not really get Context properties from Music objects, since music objects are not directly connected to Contexts. That connection is made by the Music_iterators

Can you get to Music properties from a Context object?

Yes, if you are given the music object within a Context object. Normally, the music objects enter Contexts in synchronized fashion, and the synchronization is done by Music_iterators.

What is the relationship between C++ classes and Scheme objects?

Smobs are C++ objects in Scheme. Scheme objects (lists, functions) are manipulated from C++ as well using the Guile C function interface (prefix: scm_)

How do Scheme procedures get called from C++ functions?

scm_call_*, where * is an integer from 0 to 4. Also scm_c_eval_string (), scm_eval ()

How do C++ functions get called from Scheme procedures?

Export a C++ function to Scheme with LY_DEFINE.

What is the flow of control in the program?

Good question. Things used to be clear-cut, but we have Scheme and SMOBs now, which means that interactions do not follow a very rigid format anymore. See below for an overview, though.

Does the parser make Scheme procedure calls or C++ function calls?

Both. And the Scheme calls can call C++ and vice versa. It's nested, with the SCM datatype as lubrication between the interactions

(I think the word "lubrication" describes the process better than the traditional word "glue")

How do the front-end and back-end get started?

Front-end: a file is parsed, the rest follows from that. Specifically,

Parsing leads to a Music + Music_output_def object (see parser.yy, definition of toplevel_expression)

A Music + Music_output_def object leads to a Global_context object (see ly_run_translator ())

During interpreting, Global_context + Music leads to a bunch of Contexts (see Global_translator::run_iterator_on_me ()).

After interpreting, Global_context contains a Score_context (which contains staves, lyrics etc.) as a child. Score_context::get_output () spews a Music_output object (either a Paper_score object for notation or Performance object for MIDI).

The Music_output object is the entry point for the backend (see ly_render_output ()).

The main steps of the backend itself are in

- `paper-score.cc` , Paper_score::process_
- `system.cc` , System::get_lines()
- The step, where things go from grobs to output, is in System::get_line(): each grob delivers a Stencil (a Device independent output description), which is interpreted by our outputting backends (`scm/output-tex.scm` and `scm/output-ps.scm`) to produce TeX and PS.

Interactions between grobs and putting things into .tex and .ps files have gotten a little more complex lately. Jan has implemented page-breaking, so now the backend also involves Paper_book, Paper_lines and other things. This area is still heavily in flux, and perhaps not something you should want to look at.

How do the front-end and back-end communicate?

There is no communication from backend to front-end. From front-end to backend is simply the program flow: music + definitions gives contexts, contexts yield output, after processing, output is written to disk.

Where is the functionality associated with KEYWORDs?

See `my-lily-lexer.cc` (keywords, there aren't that many) and `ly/*.ly` (most of the other backslashed `/\words` are identifiers)

What Contexts/Properties/Music/etc. are available when they are processed?

What do you mean exactly with this question?

See `ly/engraver-init.ly` for contexts, see `scm/define-*.scm` for other objects.

How do you decide if something is a Music, Context, or Grob property?

Why is part-combine-status a Music property when it seems (IMO) to be related to the Staff context?

The Music_iterators and Context communicate through two channels

Music_iterators can set and read context properties, idem for Engravers and Contexts

Music_iterators can send "synthetic" music events (which aren't in the input) to a context. These are caught by Engravers. This is mostly a one way communication channel.

part-combine-status is part of such a synthetic event, used by Part_combine_iterator to communicate with Part_combine_engraver.

Deciding between context and music properties

I'm adding a property to affect how \autoChange works. It seems to me that it should be a context property, but the Scheme autoChange procedure has a Music argument. Does this mean I should use a Music property?

\autoChange is one of these extra strange beasts: it requires look-ahead to decide when to change staves. This is achieved by running the interpreting step twice (see `scm/part-combiner.scm` , at the bottom), and storing the result of the first step (where to switch staves) in a Music property. Since you want to influence that where-to-switch list, your must affect the code in make-autochange-music (`scm/part-combiner.scm`). That code is called directly from the parser and there are no official "parsing properties" yet, so there is no generic way to tune \autoChange. We would have to invent something new for this, or add a separate argument,

```
\autoChange #around-central-C ..music..
```

where around-central-C is some function that is called from make-autochange-music.

More on context and music properties

From Neil Puttock, in response to a question about transposition:

Context properties (using \set & \unset) are tied to engravers: they provide information relevant to the generation of graphical objects.

Since transposition occurs at the music interpretation stage, it has no direct connection with engravers: the pitch of a note is fixed before a notehead is created. Consider the following minimal snippet:

```
{ c' }
```

This generates (simplified) a NoteEvent, with its pitch and duration as event properties,

```
(make-music
  'NoteEvent
  'duration
  (ly:make-duration 2 0 1 1)
  'pitch
  (ly:make-pitch 0 0 0)
```

which the Note_heads_engraver hears. It passes this information on to the NoteHead grob it creates from the event, so the head's correct position and duration-log can be determined once it's ready for printing.

If we transpose the snippet,

```
\transpose c d { c' }
```

the pitch is changed before it reaches the engraver (in fact, it happens just after the parsing stage with the creation of a TransposedMusic music object):

```
(make-music
 'NoteEvent
 'duration
 (ly:make-duration 2 0 1 1)
 'pitch
```

```
(ly:make-pitch 0 1 0)
```

You can see an example of a music property relevant to transposition: untransposable.

```
\transpose c d { c'2 \withMusicProperty #'untransposable ##t c' }
```

-> the second c' remains untransposed.

Take a look at `lily/music.cc` to see where the transposition takes place.

How do I tell about the execution environment?

I get lost figuring out what environment the code I'm looking at is in when it executes. I found both the C++ and Scheme autoChange code. Then I was trying to figure out where the code got called from. I finally figured out that the Scheme procedure was called before the C++ iterator code, but it took me a while to figure that out, and I still didn't know who did the calling in the first place. I only know a little bit about Flex and Bison, so reading those files helped only a little bit.

Han-Wen: GDB can be of help here. Set a breakpoint in C++, and run. When you hit the breakpoint, do a backtrace. You can inspect Scheme objects along the way by doing

```
p ly_display_scm(obj)
```

this will display OBJ through Guile.

10.19.3 Music functions and Guile debugging

Ian Hulin was trying to do some debugging in music functions, and came up with the following question (edited and adapted to current versions):

HI all, I'm working on the Guile Debugger Stuff, and would like to try debugging a music function definition such as:

```
conditionalMark =
#(define-music-function () ()
  #{ \tag instrumental-part {\mark \default} #} )
```

It appears `conditionalMark` does not get set up as an equivalent of a Scheme

```
(define conditionalMark = define-music-function () () ...
```

although something gets defined because Scheme apparently recognizes

```
#(set-break! conditionalMark)
```

later on in the file without signalling any Guile errors.

However the breakpoint trap is never encountered as `define-music-function` passed things on to `ly:make-music-function`, which is really C++ code `ly_make_music_function`, so Guile never finds out about the breakpoint.

The answer in the mailing list archive at that time was less than helpful. The question already misidentifies the purpose of `ly:make-music-function` which is only called once at the time of *defining* `conditionalMark` but is not involved in its later *execution*.

Here is the real deal:

A music function is not the same as a Guile function. It boxes both a proper Scheme function (with argument list and body from the `define-music-function` definition) along with a call signature representing the *types* of both function and arguments.

Those components can be reextracted using `ly:music-function-extract` and `ly:music-function-signature`, respectively.

When LilyPond's parser encounters a music function call in its input, it reads, interprets, and verifies the arguments individually according to the call signature and *then* calls the proper Scheme function.

While it is actually possible these days to call a music function *as if* it were a Scheme function itself, this pseudo-call uses its own wrapping code matching the argument list *as a whole* to the call signature, substituting omitted optional arguments with defaults and verifying the result type.

So putting a breakpoint on the music function itself will still not help with debugging uses of the function using LilyPond syntax.

However, either calling mechanism ultimately calls the proper Scheme function stored as part of the music function, and that is where the breakpoint belongs:

```
#(set-break! (ly:music-function-extract conditionalMark))
```

will work for either calling mechanism.

10.19.4 Articulations on EventChord

From David Kastrup's email `https://lists.gnu.org/archive/html/lilypond-devel/2012-02/msg00189.html`:

LilyPond's typesetting does not act on music expressions and music events. It acts exclusively on stream events. It is the act of iterators to convert a music expression into a sequence of stream events played in time order.

The EventChord iterator is pretty simple: it just takes its "elements" field when its time comes up, turns every member into a StreamEvent and plays that through the typesetting process. The parser currently appends all postevents belonging to a chord at the end of "elements", and thus they get played at the same point of time as the elements of the chord. Due to this design, you can add per-chord articulations or postevents or even assemble chords with a common stem by using parallel music providing additional notes/events: the typesetter does not see a chord structure or postevents belonging to a chord, it just sees a number of events occuring at the same point of time in a Voice context.

So all one needs to do is let the EventChord iterator play articulations after elements, and then adding to articulations in EventChord is equivalent to adding them to elements (except in cases where the order of events matters).

11 Release work

11.1 Development phases

There are 2 states of development on `master`:

1. **Normal development**: Any commits are fine.
2. **Build-frozen**: Do not require any additional or updated libraries or make non-trivial changes to the build process. Any such patch (or branch) may not be merged with master during this period.

   This should occur approximately 1 month before any alpha version of the next stable release, and ends when the next unstable branch begins.

After announcing a beta release, branch `stable/2.x`. There are 2 states of development for this branch:

1. **Normal maintenance**: The following patches **MAY NOT** be merged with this branch:
   - Any change to the input syntax. If a file compiled with a previous `2.x` (beta) version, then it must compile in the new version.

     Exception: any bugfix to a Critical issue.
   - New features with new syntax *may be committed*, although once committed that syntax cannot change during the remainder of the stable phase.
   - Any change to the build dependencies (including programming libraries, documentation process programs, or python modules used in the buildscripts). If a contributor could compile a previous lilypond `2.x`, then he must be able to compile the new version.
2. **Release prep**: Only translation updates and important bugfixes are allowed.

11.2 Release checklist

A "minor release" means an update of *y* in `2.x.y`.

Preparing the release

1. Prepare the release branch (`release/unstable` for unstable releases or `stable/2.x` for stable releases). It is recommended to use a separate repository for this, or at least a worktree. The checked out repository must have no changes to tracked files.
   - Pull the latest changes in the remote repository, then switch to and update the branch:

     ```
     git fetch origin
     git rebase origin/master release/unstable
     ```

     (adapt as necessary for `stable/2.x`)
   - Remove untracked files from the repository, especially the `configure` script:

     ```
     git clean -dfx --exclude release/
     ```

     (Keep untracked files in the `release/` directory, such as `release/binaries/downloads/` and local test builds.)
2. Generate the `configure` script and run it:

   ```
   ./autogen.sh
   ```
3. Update the translation template `po/lilypond.pot`:

   ```
   make po-replace
   ```
4. Edit the news files:
   - Copy the previous announcement from `Documentation/en/web/news-new.itexi` to `Documentation/en/web/news-old.itexi`.

- Create a new announcement in `Documentation/en/web/news-new.itexi` by adjusting the version number and the date.
- Adjust the headlines in `Documentation/en/web/news-headlines.itexi` accordingly.

5. Adjust version numbers in `VERSION`. In most cases, this means setting `VERSION_DEVEL` to the current version. Only change `VERSION_STABLE` if releasing a stable version.
6. Commit the changes:

```
git commit -m "po: Update template" -- po/lilypond.pot
git commit -m "web: Update news" -- Documentation/en/web/
git commit -m "Bump VERSION_DEVEL" -- VERSION
```

Creating the source release

1. Remove untracked files from the repository (see above):

```
git clean -dfx --exclude release/
```

2. Generate the `configure` script and run it:

```
./autogen.sh
```

3. Create the source tarball:

```
make dist
```

The last step creates `out/lilypond-2.x.y.tar.gz`, which will be the "single source of truth" for the following steps. Put it into a directory for the final upload step.

Building the binaries and documentation

These steps can be run in any order, or in parallel, with the exception of the Windows (mingw) build, that needs a run of the Linux build before.

- Build binaries on "native" platforms (Linux and macOS) with the scripts in `release/binaries/` *from the tarball*:

```
./build-dependencies && ./build-lilypond /path/to/lilypond-2.x.y.tar.gz
```

- Build binaries for Windows (needs a run of the previous step on Linux):

```
./build-dependencies --mingw && ./build-lilypond --mingw /path/to/lilypond-2.x.y.ta
```

- Build the documentation using `release/doc/build-doc.sh`:

```
./build-doc.sh /path/to/lilypond-2.x.y.tar.gz
```

Collect all created binaries (`.tar.gz` and `.zip`) and documentation archives (`.tar.xz`) in the directory next to the source tarball. If possible, give them some short testing to make sure everything works as expected.

Uploading the release

During this step, the artifacts from the previous steps are uploaded to `lilypond.org` and GitLab for the world to see. Make sure everything is ready before proceeding.

1. Create a personal access token at `https://gitlab.com/-/user_settings/personal_access_tokens` and select the 'api' scope (complete read/write access). The token can be limited to auto-expire the next day.
2. Upload the source tarball to `lilypond.org`:

```
scp lilypond-2.x.y.tar.gz graham@gcp.lilypond.org:/var/www/lilypond/downloads/sourc
```

3. In the directory where you collected the binaries, run the script to upload the files to GitLab:

```
/path/to/lilypond/release/upload.py --token TOKEN 2.x.y
```

4. Upload the documentation to `lilypond.org`:

```
/path/to/lilypond/release/doc/upload-webdoc.sh 2.x.y
```

Tagging and announcing the release

1. In the repository that was used to create the release (check that `git log` has the expected commits; "Bump VERSION_DEVEL" should be the last one), tag the release:

   ```
   git tag -am "LilyPond 2.x.y" v2.x.y
   ```

2. Push the changes and the tag:

   ```
   git push origin HEAD:release/unstable v2.x.y
   ```

   (adapt as necessary for `stable/2.x`)

3. Create a file `description.md` with a copy of the release announcement (may be formatted as Markdown for links).

4. Create the release on GitLab:

   ```
   /path/to/lilypond/release/create-release.py --token TOKEN --description description
   ```

Creating a release on GitLab will automatically send an email to everbody who subscribed to release notifications.

Post unstable release

In this case, the release branch is `release/unstable`.

1. Update the `master` branch with the latest changes:

   ```
   git fetch origin
   git rebase origin/master master
   ```

2. Merge the release branch:

   ```
   git merge --no-ff release/unstable
   ```

3. Bump `PATCH_LEVEL` in the `VERSION` file and commit:

   ```
   git commit -m "Bump VERSION" -- VERSION
   ```

4. Push the branch to GitLab:

   ```
   git push origin HEAD:release/unstable
   ```

5. Create a merge request from `release/unstable` to merge the changes into `master`.

6. Update the website as described in Section 6.2 [Uploading website], page 62.

7. Update the milestones at GitLab:

   1. Make sure all merge requests and issues are added to the milestone of the released version. Fill in the due date and close it.
   2. Create a new milestone for the next release (unless no more bugfix release is planned) and set the start date.

8. Check open merge requests and remind people to update the `\version` statement in conversion rules and regression tests.

After the website update appears on `lilypond.org`, send a release notice to `lilypond-devel` and `lilypond-user` with the same announcement text and possibly further instructions.

11.3 Major release checklist

A "major release" means an update of `x` in `2.x.0`.

Main requirements

These are the current official guidelines.

- 0 Critical issues for two weeks (14 days) after the latest release candidate.

Potential requirements

These might become official guidelines in the future.

- Check reg test
- Check all 2ly scripts
- Check for emergencies the docs:

```
grep FIXME --exclude "misc/*" --exclude "*GNUmakefile" \
  --exclude "snippets/*" ????*/*
```

- Check for altered regtests, and document as necessary:

```
git diff -u -r release/2.FIRST-CURRENT-STABLE \
  -r release/2.LAST-CURRENT-DEVELOPMENT input/regression/
```

Housekeeping requirements

Before the release:

- write release notes. note: stringent size requirements for various websites, so be brief.
- Run convert-ly on all files, bump parser minimum version.
- Update lilypond.pot:

```
make -C $LILYPOND_BUILD_DIR po-replace
mv $LILYPOND_BUILD_DIR/po/lilypond.pot po/
```

- Make directories on lilypond.org:

```
~/download/sources/v2.NEW-STABLE
~/download/sources/v2.NEW-DEVELOPMENT
```

Shortly after the release:

- Move all current contributors to previous contributors in `Documentation/en/included/authors.itexi`.
- Delete old material in `Documentation/en/changes.tely`, but don't forget to check it still compiles! Also update the version numbers:

```
@node Top
@top New features in 2.NEW-STABLE since 2.OLD-STABLE
```

- Update the version of the search boxes in the Table of Contents sidebar to 2.*NEW-DEVELOPMENT* (in `Documentation/lilypond.init`).
- Prevent crawlers from indexing the old documentation by adding lines to `Documentation/webserver/robots.txt` until:

```
Disallow: /doc/v2.OLD-STABLE/
```

  Do *not* yet add a line for 2.*OLD-DEVELOPMENT* because the search for the documentation of 2.*NEW-STABLE* relies on it!
- Update the htaccess redirections (`/latest/`, `/stable/`, etc.) in `Documentation/webserver/lilypond.org.htaccess`.
- Add a link to the previous stable version's announcement, list of changes and contributors acknowledgements to the 'Attic' page, in `Documentation/en/web/community.itexi`.
- Add a link to the previous stable version's documentation to `Documentation/en/web/manuals.itexi`.

Unsorted

- submit po template for translation: send url of tarball to `coordinator@translationproject.org`, mentioning lilypond-VERSION.pot

- Send announcements to...

  News:

  ```
  comp.music.research
  comp.os.linux.announce

  comp.text.tex
  rec.music.compose
  ```

  Mail:

  ```
  info-lilypond@gnu.org
  info-gnu@gnu.org
  planet@gnu.org

  linux-audio-announce@lists.linuxaudio.org
  linux-audio-user@lists.linuxaudio.org
  linux-audio-dev@lists.linuxaudio.org
  consortium@lists.linuxaudio.org
  planetccrma@ccrma.stanford.edu

  tex-music@tug.org

  rosegarden-user@lists.sourceforge.net
  denemo-devel@gnu.org
  ```

  Web (forums):

  ```
  imslpforums.org
  abcusers (Yahoo group)
  canorus (Github? Freenode IRC?)
  musescore.org/forum
  reddit.com/lilypond
  linuxquestions.org
  Slashdot
  ```

  Web (websites and aggregators):

  ```
  lilypond.org
  https://savannah.gnu.org/news/submit.php?group_id=1673
  freshmeat.sourceforge.net
  linuxtoday.com
  lxer.com
  fossmint.com
  fsdaily.com
  freesoftwaremagazine.com
  lwn.net
  hitsquad.com/smm

  in French: linuxfr.org; framalibre.org
  ```

12 Modifying the Emmentaler font

12.1 Overview of the Emmentaler font

Emmentaler was created specifically for use in LilyPond. The font consists of two *sub-sets* of glyphs. “Feta”, used for clasical notation and “Parmesan”, used for Ancient notation. The sources of which are all found in mf/*.mf.

The font is merged from a number of subfonts. Each subfont can contain at most 224 glyphs. This is because each subfont is limited to a one-byte address space (256 glyphs maximum) and we avoid the first 32 points in that address space, since they are non-printing control characters in ASCII.

In LilyPond, glyphs are accessed by a ‘glyph name’, rather than by code point. Therefore, the name of a glyph is significant.

Information about correctly creating glyphs is found in `mf/README`. Please make sure you read and understand this file.

TODO – we should get mf/README automatically generated from texinfo source and include it here.

12.2 Font creation tools

The sources for Emmentaler are written in metafont. The definitive reference for metafont is "The METAFONT book" – the source of which is available at CTAN.

mf2pt1 is used to create type 1 fonts from the metafont sources.

FontForge is used to postprocess the output of mf2pt1 and clean up details of the font. It can also be used by a developer to display the resulting glyph shapes.

12.3 Adding a new font section

The font is divided into sections, each of which contains less than 224 glyphs. If more than 224 glyphs are included in a section, an error will be generated.

Each of the sections is contained in a separate `.mf` file. The files are named according to the type of glyphs in that section.

When adding a new section, it will be necessary to add the following:

- The code for the glyphs, in a file `<section-name>.mf`
- Driver files used to create the font in different sizes
- An entry in the generic file used to create the font, or a new generic file
- If necessary, new entries in the GNUmakefile
- An entry in `scripts/build/gen-emmentaler-scripts.py`

See the examples in `mf/` for more information.

12.4 Adding a new glyph

Adding a new glyph is done by modifying the .mf file to which the glyph will be added.

Necessary functions to draw the glyph can be added anywhere in the file, but it is standard to put them immediately before the glyph definition.

The glyph definition begins with:

```
fet_beginchar ("glyph description", "glyphname");
```

with `glyph description` replaced with a short description of the glyph, and `glyphname` replaced with the glyphname, which is chosen to comply with the naming rules in `mf/README`.

The metafont code used to draw the glyph follows the `fet_beginchar` entry. The glyph is finished with:

```
fet_endchar;
```

12.5 Building the changed font

In order to rebuild the font after making the changes, the existing font files must be deleted. The simplest and quickest way to do this is to do:

```
rm mf/out/*
make
```

12.6 METAFONT formatting rules

There are special formatting rules for METAFONT files.

Please do not use tabs for the indentation of commands.

When a path contains more than two points, put each point on a separate line, with the operator at the beginning of the line. The operators are indented to the same depth as the initial point on the path using spaces. The indentation mechanism is illustrated below.

```
def draw_something (expr test) =
  set_char_box (staff_space#, 1.6 linethickness# / 2,
                0.5 staff_space#, 0.5 staff_space#);
  if test:
    fill z1
         -- z2
         -- z3
         .. cycle;
  fi;
enddef;
```

13 Administrative policies

This chapter discusses miscellaneous administrative issues which don't fit anywhere else.

13.1 LilyPond is GNU Software

LilyPond is a GNU software package. As such, it falls under the requirements found in the GNU Coding Standards (`https://www.gnu.org/prep/standards/`). All suggested changes should move toward increased compliance with these Standards.

13.2 Environment variables

Some maintenance scripts and instructions in this guide rely on the following environment variables. They should be predefined in LilyDev distribution (see Section 2.1 [LilyDev], page 5); if you set up your own development environment, you can set them by appending these settings to your `~/.bashrc` (or whatever defines your default environment variables for the user account for LilyPond development), then logging out and in (adapt directories to your setup):

```
LILYPOND_GIT=~/lilypond-git
export LILYPOND_GIT
LILYPOND_BUILD_DIR=~/lilypond-git/build
export LILYPOND_BUILD_DIR
```

The standard build and install procedure (with `autogen.sh`, `configure`, `make`, `make install`, `make doc ...`) does not rely on them.

13.3 Performing yearly copyright update ("grand-replace")

At the start of each year, copyright notices for all source files should be refreshed by running the following command from the top of the source tree:

```
make grand-replace
```

Internally, this invokes the script `scripts/build/grand-replace.py`, which performs a regular expression substitution for old-year -> new-year wherever it finds a valid copyright notice.

Note that snapshots of third party files such as `texinfo.tex` should not be included in the automatic update; `grand-replace.py` ignores these files if they are listed in the variable `copied_files`.

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Version 1.3, 3 November 2008

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