

Princeton University

COS 217: Introduction to Programming Systems

Emacs Reference and Tutorial

Part 1: Reference

This reference assumes that Emacs is configured using the .emacs file provided to COS 217 students.

To type "Ctrl-*somechar*" (for any character *somechar*), type the *somechar* key while holding down the Ctrl key. To type "Esc *somechar*" (for any character *somechar*), type the Esc key followed by the *somechar* key.

On a Microsoft Windows computer using PuTTY, typing "Alt- *somechar* " has the same effect as typing "Esc *somechar*". On a Mac using Terminal, that's true if and only if you have configured your Terminal application appropriately: from the Terminal application's menu choose Terminal | Preferences... | Settings | Keyboard and make sure the "Use option as meta key" checkbox is checked.

In Emacs all work is accomplished by calling functions. To call a function, type "Esc *xfunction*". Many functions are bound to keystrokes. Commonly used functions are in **boldface**.

Moving the Point

| Binding | Function | Description |
|---------------|----------------------------|--|
| → | forward-char | Move the point forward one character |
| ← | backward-char | Move the point backward one character |
| ↓ | next-line | Move the point to the next line |
| ↑ | previous-line | Move the point to the previous line |
| Ctrl-f | forward-char | Move the point forward one character |
| Ctrl-b | backward-char | Move the point backward one character |
| Ctrl-n | next-line | Move the point to next line |
| Ctrl-p | previous-line | Move the point to previous line |
| Esc f | forward-word | Move the point to next word |
| Esc b | backward-word | Move the point to previous word |
| Home | beginning-of-line | Move the point to beginning of line (but not with some terminal apps) |
| End | end-of-line | Move the point to end of line (but not with some terminal apps) |
| Ctrl-a | beginning-of-line | Move the point to beginning of line |
| Ctrl-e | end-of-line | Move the point to end of line |
| Esc a | c-beginning-of-statement | Move the point to the beginning of C statement |
| Esc e | c-end-of-statement | Move the point to the end of C statement |
| PageDn | scroll-up | Move the point to next page (but not with some terminal apps) |
| PageUp | scroll-down | Move the point to previous page (but not with some terminal apps) |
| Ctrl-v | scroll-up | Move the point to next page |
| Esc v | scroll-down | Move the point to previous page |
| Esc < | beginning-of-buffer | Move the point to beginning of the buffer |
| Esc > | end-of-buffer | Move the point to end of the buffer |
| Esc Ctrl-a | beginning-of-defun | Move the point to beginning of the C function |
| Esc Ctrl-e | end-of-defun | Move the point to end of the C function |
| Ctrl-x l line | goto-line | Move the point to line whose number is <i>line</i> |

Inserting and Deleting

| Binding | Function | Description |
|---------------|----------------------------------|--|
| Bsp | c-electric-backspace | Delete the character before the point |
| Esc Bsp | backward-kill-word | Delete the characters from the point to the beginning of the word |
| Ctrl-d | c-electric-delete-forward | Delete the character at the point |
| Ctrl-k | kill-line | Cut the current line |
| Ctrl-Sp | set-mark-command | Set the mark at the point |
| Ctrl-x Ctrl-x | exchange-point-and-mark | Exchange the mark and the point |
| Ctrl-x h | mark-whole-buffer | Set the point at the beginning and the mark at the end of the buffer |
| Ctrl-w | kill-region | Cut the region denoted by the mark and the point |
| Esc w | kill-ring-save | Copy the region denoted by the mark and the point |
| Ctrl-y | yank | Paste the previously cut/copied region at the point |

Saving and Exiting

| Binding | Function | Description |
|---------------------------|--------------------------------|--|
| Ctrl-x Ctrl-s | save-buffer | Save the current buffer to its file |
| Ctrl-x Ctrl-w <i>file</i> | write-file | Write the current buffer to <i>file</i> |
| Ctrl-x Ctrl-q | vc-toggle-read-only | Toggle the current buffer between read-only and read/write |
| Ctrl-x Ctrl-c | save-buffers-kill-emacs | Save all buffers and exit Emacs |

Indenting

| Binding | Function | Description |
|-----------------|-------------------------|--|
| Ctrl-c . | c-set-style | Set the C indentation style to the specified one |
| TAB | c-indent-command | Indent the current line of the C program |
| Esc Ctrl-\ | indent-region | Indent the region of the C program denoted by the mark and the point |
| Ctrl-x p | indent-all | Indent all lines of the C program (i.e. indent the program perfectly) |

Searching and Replacing

| Binding | Function | Description |
|-----------------------------|------------------------|--|
| Ctrl-s <i>string</i> | isearch-forward | Search forward for <i>string</i> |
| Ctrl-r <i>string</i> | isearch-backward | Search backward for <i>string</i> |
| Esc % <i>old new</i> | query-replace | Replace the <i>old</i> string with the <i>new</i> one y => replace n => skip ! => replace all q => quit |

Managing Windows and Buffers

| Binding | Function | Description |
|----------------------------------|--------------------------------|---|
| Ctrl-x Ctrl-f <i>file</i> | find-file | Load <i>file</i> into a buffer |
| Ctrl-x Ctrl-r <i>file</i> | find-file-read-only | Load <i>file</i> into a buffer for read only |
| Ctrl-x 2 | split-window-vertically | Split the current window into two windows arranged vertically |
| Ctrl-x o | other-window | Move the point to the other window |
| Ctrl-x 3 | split-window-horizontally | Split the current window into two windows arranged horizontally |
| Ctrl-x 0 | delete-window | "Undisplay" the current window |
| Ctrl-x 1 | delete-other-windows | "Undisplay" all windows except the current one |
| Ctrl-x Ctrl-b | list-buffers | Display a new window listing all buffers |
| Ctrl-x b <i>file</i> | switch-to-buffer | Load <i>file</i> into a buffer if necessary, and then display that buffer in the current window |

Building and Debugging

| Binding | Function | Description |
|---------|---------------------------|---|
| | compile-command | Build the program using <i>command</i> |
| | gdb executablefile | Launch the GDB debugger to debug <i>executablefile</i> |

Miscellaneous

| Binding | Function | Description |
|--------------------------|----------------------|---|
| Ctrl-x u | undo | Undo the previous change |
| Ctrl-u | undo | Undo the previous change |
| Ctrl-g | keyboard-quit | Abort the multi-keystroke command |
| Ctrl-h | help-command | Access the Emacs help system |
| Esc ` | tm-m-menubar | Access the Emacs menu |
| Ctrl-x n | linum | Display/undisplay a line number before each line |

Part 2: Tutorial

This tutorial describes how to use a minimal subset of the Emacs editor. See the preceding Emacs reference for more information. Also see the "GNU Emacs Tutorial" document at <http://www.gnu.org/software/emacs/tour>. Throughout this tutorial text in **boldface** indicates hands-on activities.

This tutorial assumes that you've copied the file `/u/cos217/.emacs` to your home directory, as described in the "A Minimal COS 217 Computing Environment" handout from our first precept. It also assumes that you've copied files named `hello.c`, `circle.c`, and `testintmath.c` into your working directory. (Those files contain C programs that we'll describe in upcoming precepts.) Those files are available in the directory `/u/cos217/emacs_testfiles`. You can issue this command:

```
cp /u/cos217/emacs_testfiles/* .
```

to copy them to your working directory. Throughout the tutorial text in **boldface** indicates hands-on activities.

Background

Emacs was created in the mid 1970s by Richard Stallman. Originally it was a set of "editing macros" for an editor that now is extinct.

Emacs is popular, for a few reasons. Emacs is:

- Free. It's a component of the GNU tool set from the Free Software Foundation.
- Highly customizable. Emacs is written in the LISP programming language, and is easy to customize via that language.
- Integrated with other GNU software. In particular, Emacs is integrated with the Bash history mechanism. Essentially you can think of the Bash history list as a "file"; you can use Emacs commands to scroll through and edit that file, and thereby easily reissue previous commands or variants thereof. Emacs also is integrated with the GCC compiler driver, as this tutorial describes. Finally, and probably most importantly, Emacs is integrated with GDB debugger. A future precept will describe that integration.

Emacs is a *modal* editor. That is, at any given time, Emacs is in one of several modes. In the COS 217 course you will use C mode, Assembler mode, Text mode, GNUmakefile mode, and Fundamental mode. If the current file's name ends with `.c`, then Emacs will be in C mode; if the current file's name ends with `.s`, then Emacs will be in Assembler mode; if the current file's name ends with `.txt`, then Emacs will be in Text mode; if the current file's name is `makefile` or `Makefile`, then Emacs will be in GNUmakefile mode. By default, Emacs is in Fundamental mode. This tutorial illustrates C mode.

Launching Emacs

To launch Emacs, issue the `emacs` command followed by the name of the file that you wish to create or edit. For example, **issue this command at the Bash prompt:**

```
emacs testintmath.c
```

Emacs loads the contents of the `testintmath.c` into a buffer in memory, and displays that buffer in the window. It places the point over the first character in the first line of the buffer.

Note the Emacs terminology: A *buffer* is an area of memory. A *window* is a graphical entity that displays the contents of a specified buffer. The *point* is a small black box which overlays a character, thus indicating which character is the "current" character.

Notation

Throughout this document:

- "Esc *somechar*" means "type the Esc key followed by the *somechar* key."
- "Ctrl-*somechar*" means "type the *somechar* key while holding down the Ctrl key."

for any character *somechar*.

Incidentally, on a Microsoft Windows computer using PuTTY, "Alt-*somechar*" (that is, typing the *somechar* key while holding down the Alt key) has the same effect in Emacs as "ESC *somechar*" does. On a Mac that's true if and only if you have configured your Terminal application appropriately: from the Terminal application's menu choose Terminal | Preferences... | Settings | Keyboard and make sure the "Use option as meta key" checkbox is checked.

The .emacs File

When you launch Emacs, it looks for a file named .emacs in your home directory. If Emacs finds that file, it assumes that the file contains configuration function calls, and executes them.

Take a look at the .emacs file that you've copied to your home directory. **Issue the command "cat .emacs"** to do that. The file is thoroughly commented; please study it at your leisure. In particular, note this line:

```
(setq c-default-style "ellemtel")
```

As described below, Emacs automatically indents your C code according to whatever indentation style you specify. That line sets the indentation style to "ellemtel." The commented-out lines that immediately follow in the .emacs file show the names of some other styles. Any of those styles is fine in the context of the COS 217 course. Experiment! See which you like best.

Calling Functions

In Emacs, all work is accomplished by calling functions. The syntax for calling a function is:

```
Esc x function
```

For example, the `forward-char` function moves the point forward one character:

```
Esc x forward-char
```

Emacs moves the point forward one character within the buffer each time you call the `forward-char` function. **Call `forward-char` a few times.**

Clearly there must be a better way to move the point! More generally, there must be a better way to call often-used functions.

Key Bindings

There indeed is a better way. The most often-used functions are bound to keystrokes.

For example, the `forward-char` function is bound to the keystroke `Ctrl-f`. **Type `Ctrl-f` a few times.** The `forward-char` function also is bound to the right-arrow key. **Type the right-arrow key a few times.**

Many keystrokes are bound by default. You also can bind your own, typically by placing a function call of this form in your `.emacs` file:

```
(global-set-key keystrokes 'function)
```

But few new Emacs users create their own keystroke bindings.

Moving the Point

The simplest way to move the point is via the `forward-char`, `backward-char`, `next-line` and `previous-line` functions, each of which is bound to an arrow key. **Type the arrow keys to move the point right, left, down, and up several times.**

The `beginning-of-line` and `end-of-line` functions have intuitive meanings. They are bound to the `Ctrl-a` and `Ctrl-e` keystrokes, respectively. They may also be bound to the `Home` and `End` keys, respectively; but `Home` and `End` may or may not work with your terminal emulation software. **Type `Ctrl-a`, `Ctrl-e`, `Home`, and `End` several times.**

Perhaps counter-intuitively, the `scroll-up` function moves the window downward in the buffer; equivalently, it moves the buffer upward in the window. The `scroll-up` function is bound to `Ctrl-v`, and also may be bound to the `PageDn` key. The `scroll-down` function moves the window upward in the buffer. That is, it moves the buffer downward in the window. The `scroll-down` function is bound to `ESC v`, and also may be bound to the `PageUp` key. **Type `Ctrl-v`, `PageDn`, `ESC v`, and `PageUp` several times.**

The `end-of-buffer` function moves the point to the end of the buffer; it is bound to `Esc >`. The `beginning-of-buffer` function moves the point to the beginning of the buffer; it is bound to the `Esc <`. **Type `Esc >` and `Esc <` several times.**

The `goto-line` function allows you to specify, by number, the line to which the point should be moved. It is bound to the `Ctrl-x 1` (that's `Ctrl-x` followed by the "ell" key) keystroke sequence. **Type `Ctrl-x 1`, followed by some reasonable line number, followed by the `Enter` key.**

Inserting and Deleting

To insert a character, move the point to the character before which the insertion should occur, and then type the character. **Move the point to some arbitrary spot in the buffer, and type some characters.**

The `c-electric-backspace` function (bound to the `Backspace` key) deletes the character before the point. **Move the point to some arbitrary spot in the buffer, and type `Backspace` several times.** The `c-electric-delete-forward` function (bound to `Ctrl-d`) deletes the character at the point. **Move the point to some arbitrary spot in the buffer, and type `Ctrl-d` several times.**

To delete a line, move the point to the beginning of the line and then call the `kill-line` function (bound to `Ctrl-k`). Calling the function once kills the characters comprising the line, but not the line's end-of-line mark. Calling the function a second time also kills the end-of-line mark. **Move the point to the beginning of some arbitrary line, and type `Ctrl-k` several times.**

Actually, the `kill-line` function doesn't completely discard the line that it kills; instead it moves the line to the Emacs clipboard. The `yank` function (bound to `Ctrl-y`) copies ("yanks") the line from the Emacs clipboard into the buffer at the point. The combination of the `kill-line` and `yank` functions provides a single-line cut-and-paste functionality, as this sequence illustrates:

- **Move the point to the beginning of some non-empty line that you wish to move.**
- **Type `Ctrl-k` twice.**
- **Move the point.**
- **Type `Ctrl-y`.**

For multiple-line cut-and-paste, you must know about Emacs *regions*. A region is an area of text that is bounded by the point and the *mark*. The `set-mark-command` function (bound to `Ctrl-Space`) sets the mark. The `kill-region` function (bound to `Ctrl-w`) moves the region to the Emacs clipboard; effectively it wipes out the region. This sequence illustrates moving multiple contiguous lines from one place to another in the buffer:

- **Move the point to the beginning of the first line that you wish to move.**
- **Type `Ctrl-Space` to set the *mark*.**
- **Move the point to the end of the last line that you wish to move. Note that Emacs highlights the *region* thus bounded by the point and the mark.**
- **Type `Ctrl-w` to "wipeout" the region. Emacs moves the region to its clipboard.**
- **Move the point to some spot in the buffer**
- **Type `Ctrl-y` to yank (that is, copy) the text from the clipboard to the buffer at the point.**

Incidentally, the "minimal computing environment" described in our first precept does not allow the use of a pointing device (mouse, touchpad, etc.) with Emacs. To use a pointing device with Emacs you can install an X Window System Server on your computer, as described in a forthcoming Piazza message.

Saving and Exiting

The `save-buffer` function (bound to `Ctrl-x Ctrl-s`) saves the buffer, that is, copies the contents of the buffer to its file on disk. **Type `Ctrl-x Ctrl-s` to save the buffer to the `testintmath.c` file.** As its name implies, the `save-buffers-kill-emacs` function (bound to `Ctrl-x Ctrl-c`) saves all Emacs buffers to their respective files on disk, and exits Emacs. (The section of this tutorial entitled "Managing Windows and Buffers" describes how you can use more than one Emacs buffer simultaneously.) **Type `Ctrl-x Ctrl-c` to exit Emacs**, thus returning to the Bash prompt.

Indenting

At this point `testintmath.c` probably is seriously mangled. So **recopy the `testintmath.c` file from the `/u/cos217/emacs-testfiles` directory to your working directory. Then issue the command `emacs testintmath.c` to relaunch Emacs to edit the `testintmath.c` file.**

Emacs automatically indents C code as you type it, according to the indentation style that you specified in your `.emacs` file.

The `c-indent-command` function (bound to the `Tab` key) indents the current line according to the chosen indentation style. Note that the `Tab` key does not insert a tab character into your file; rather it indents the current line. **Intentionally mal-indent a line, move the point to any spot within that line, and type the `Tab` key.**

The `indent-all` function (bound to `Ctrl-x p` because it indents your code *perfectly*) indents all lines of the buffer according to the chosen indentation style. **Intentionally mal-indent multiple lines scattered throughout the buffer, and then type `Ctrl-x p`.**

Searching and Replacing

The `isearch-forward` function (bound to `Ctrl-s`) incrementally searches forward through the buffer for the text that you specify. This sequence illustrates:

- **Move the point to the beginning of the buffer.**
- **Type `Ctrl-s`, followed by the text "il"**
- **Type `Ctrl-s` repeatedly.**
- **Move the point, thereby ending the search.**

The similar `isearch-backward` function (bound to `Ctrl-r`) incrementally searches backward through the buffer.

The `query-replace` function (bound to `Esc %`) incrementally replaces the "old" text that you specify with the "new" text that you specify. During execution of the function, typing "y" commands Emacs to perform the replacement and continue executing the function, "n" commands Emacs to skip the replacement and continue executing the function, "!" command Emacs to perform all replacements and stop executing the function, and "q" commands Emacs to stop (*quit*) executing the function. For example:

- **Move the point to the beginning of the buffer.**
- **Type `Esc %`, followed by "il", followed by "xxx".**
- **Type "y" and "n" a few times.**
- **Type "q".**
- **Move the point to the beginning of the buffer.**
- **Type `Esc %`, followed by "xxx", followed by "il".**
- **Type "!".**

Managing Windows and Buffers

Recall that, in Emacs jargon, a *buffer* is a region of memory, and a *window* is a graphical area which displays the contents of a buffer. So far in this tutorial you've used only one buffer and one window. More generally, at any given time, Emacs will be managing multiple buffers and will be displaying some (but not necessarily all) of them in windows.

To "find" a file means to load it into a buffer. The `find-file` function (bound to `Ctrl-x Ctrl-f`) finds the file whose name you provide. **Type `Ctrl-x Ctrl-f hello.c` followed by the **Enter** key** to load the `hello.c` file into a buffer. Then **type `Ctrl-x Ctrl-f circle.c` followed by the **Enter** key** to load the `circle.c` file into a buffer. At this point Emacs is managing three buffers; one of them is displayed in a window.

The `split-window-vertically` function (bound to `Ctrl-x 2`) splits the current window into two windows, each of which displays the same buffer. **Type `Ctrl-x 2` to split the current window into two windows.** The `other-window` function (bound to `Ctrl-x o`) moves the point to the other window. **Type `Ctrl-x o` a few times** to move the point back-and-forth between the two windows. Now **type `Ctrl-x Ctrl-f testintmath.c`** to find the `testintmath.c` file. At this point Emacs is managing three buffers; two of them are displayed in Emacs windows.

The `delete-other-window` function (bound to `Ctrl-x 1`) deletes the other window (that is, the window in which the point does not reside), thus returning Emacs to its default one-window state. **Type**

Ctrl-x o as necessary to move the point to the window that displays the `testintmath.c` buffer. Type **Ctrl-x 1** to delete the window that displays the `circle.c` buffer, leaving only the window that displays the `testintmath.c` buffer. At this point Emacs is managing three buffers; only one of them – the `testintmath.c` buffer – is displayed in a window.

With today's windowing operating systems, the ability of Emacs to manage multiple windows is less important than it used to be. However, you must know about Emacs windows to (1) use GDB within Emacs, as will be described in an upcoming precept, and (2) build within Emacs, as described in the next section of this tutorial.

Building

Most COS 217 students build (that is, preprocess, compile, assemble, and link) C programs by issuing the `gcc217` command at the shell prompt. An alternative is to build C programs by issuing the `gcc217` command from within Emacs. The alternative approach is optional in the COS 217 course.

The `compile` function (no keystroke binding) builds a C program from within Emacs using whatever command you specify. This sequence illustrates:

- Intentionally introduce some compiletime errors into `testintmath.c`. Specifically, **change the return type of the `gcd()` function from "int" to "it", and change the last line of the `gcd()` function from "return iFirst" to "retrn iFirst"**.
- **Type Ctrl-x Ctrl-s** to save the `testintmath.c` buffer to disk.
- **Type Esc x compile**. Emacs assumes that you wish to use the "make -k" command to build. At this point in the course, that's incorrect. So **type the Backspace key repeatedly** to delete that command. **Then type:**
`gcc217 testintmath.c -o testintmath.`
- **Type the Enter key**. Emacs opens a "compilation" window, displaying error messages.
- **Type Ctrl-x o** to move the point to the compilation window.
- **Move the point to one of the error messages, and type the Enter key**. Emacs moves the point to the other window, to the offending line.
- **Correct the offending line.**
- **Use the same approach to correct the second offending line**, and thus build successfully.

Miscellaneous Functions

The `undo` function (bound to `Ctrl-_`) undoes the previously executed function. **Move the point to some arbitrary spot in the buffer, type the Backspace key** to delete a character, and then **type Ctrl-_** to undo that change.

The `keyboard-quit` function (bound to `Ctrl-g`) aborts a multi-keystroke function call. **Type Ctrl-x** to begin a keystroke sequence that calls a function; then **type Ctrl-g** to abort the function call. **Type Esc x** to begin a keystroke sequence that calls a function; then **type Ctrl-g** to abort the function call.

The `linum` function (bound to `Ctrl-x n`) toggles the display of line numbers on the left side of the window. **Type Ctrl-x n** to display line numbers; then **type Ctrl-x n** to undisplay them.

Type Ctrl-x Ctrl-c to save all buffers and exit Emacs, thus ending the tutorial.