Introduction to Awk

ComS 252 — Iowa State University

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We need something stronger than `grep`

AWK

- Small scripting language
  - POSIX now specifies a standard for the language
  - Programs are often very short (and cryptic), e.g.:

    ```
    $3 ~ /bob/ {print $9}
    ```

    You will understand this program by the end of lecture
- Named for its inventors
  - Aho, Weinberger, Kernighan
  - The same Kernighan of “Kernighan and Ritchie” C
- Great for editing streams
- There are multiple implementations of the AWK language
  - This lecture uses a generic “awk”
- Often used in pipelines
  - E.g., `crazy | pipeline | awk ... | other | things`

AWK input stream

AWK assumes the input stream is structured as follows:

- The input files are divided into one or more records
  - Default: each line of a file is a record
  - The "record separator" may be changed (default is "newline character")
- Each record is divided into one or more fields
  - The number of fields may be different, for each record
  - Default: fields are separated by "whitespace"
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You can imagine the input stream as a table

- Rows of the table are records
- Columns of the table are fields

Running AWK programs

```
awk 'program' file1 ... filen
```

- Pass the entire program as the first argument
  - Programs can be short, remember?
  - Single quotes: otherwise need escapes
- The remaining arguments: input files
  - Processed by the program
  - If none: reads from standard input

```
awk -f progfile file1 ... filen
```

- Use `-f` to read the program from `progfile`
  - Good for complex, multi–line programs

AWK scripts

- # is a comment line in AWK programs. So. . .
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AWK scripts

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For example, if we have an executable text file:

progfile

```
#!/usr/bin/awk -f
# AWK program here
```

then running

```
prompt$ ./progfile file
```

is the same as

```
prompt$ /usr/bin/awk -f ./progfile file
```

AWK programs

- Programs follow a different model than “general” languages
- Programs operate on the input files
    - One record at a time
- AWK programs are a sequence of statements
- Statements specify
    - Which records they apply to
    - Instructions to execute for those records

AWK statements

Generic syntax

which-records { instructions }

- For the cryptic 1–line example: "`$3 ~ /bob/ {print $9}`"

  `$3 ~ /bob/` specifies which records

  `{print $9}` says what to do with the matching records
- "which-records" is optional
  - Default is: apply to all records
- "instructions" are optional, if "which-records" is given
  - Default is: print the record
- To be a proficient AWK programmer, need to know
  - How to specify "which-records"
  - What instructions can be written

Field specifiers

$1 : field 1 of the current record

$2 : field 2 of the current record

⋮

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`$0` :

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$10 : field 10 of the current record

$11 : field 11 of the current record

⋮

$0 : the entire record

`print` instruction

`print item item item ...`

- Prints text (to standard output)
- Items to print are concatenated
- No items? Prints the current record

What are possible items?

- Fields
  - E.g., `print $9`
    prints field 9 of the current record
- Literal strings, in double quotes
  - E.g, `print "Hello world!"`
    prints "Hello, world!"
- Others . . .

Example AWK program

```
{print "Hello, world!"}
```

What does this do?

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```
prompt$ █
```

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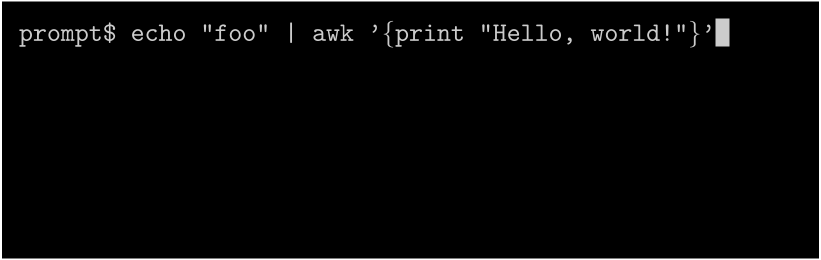

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prompt$ echo "foo" | awk '{print "Hello, world!"}'
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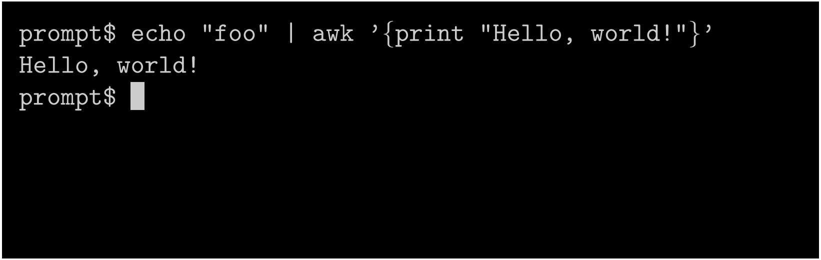

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prompt$ █
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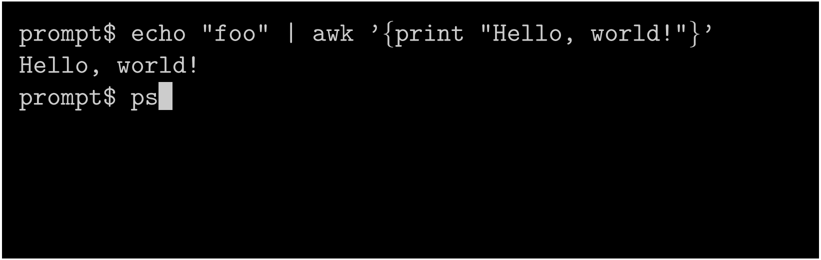

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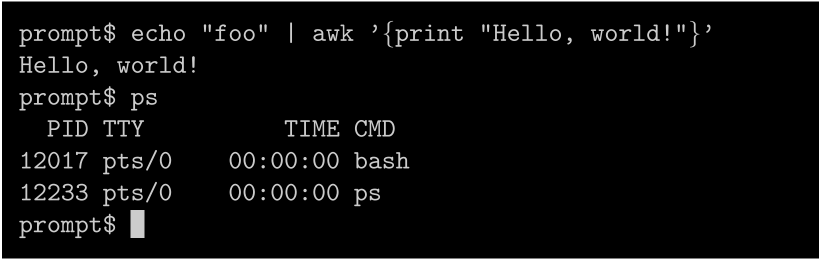

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prompt$ echo "foo" | awk '{print "Hello, world!"}'
Hello, world!
prompt$ ps
  PID TTY          TIME CMD
12017 pts/0    00:00:00 bash
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prompt$ █
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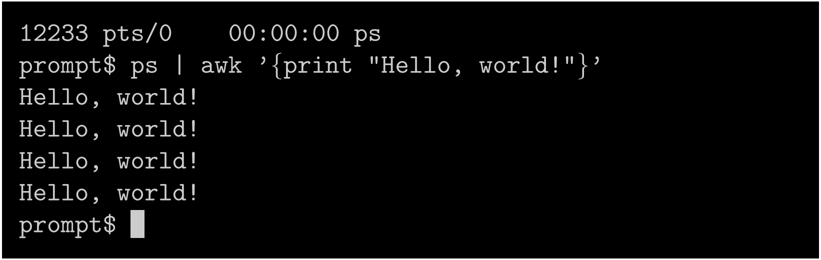

```
12233 pts/0    00:00:00 ps
prompt$ ps | awk '{print "Hello, world!"}'
Hello, world!
Hello, world!
Hello, world!
Hello, world!
prompt$ █
```

Another example AWK program

```
{print "Process " $1 " is " $4 "."}
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prompt$ █
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- For every record,
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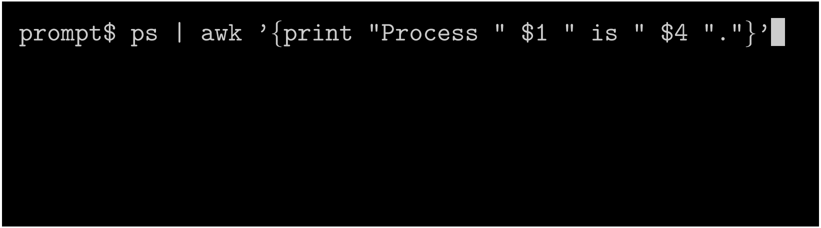

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prompt$ ps | awk ’{print "Process " $1 " is " $4 "."}’
Process PID is CMD.
Process 12017 is bash.
Process 12237 is ps.
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prompt$ █
```

Using a program file

prog1.awk

```
{ print "Process " $1 " is " $4 "." }
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prompt$ 
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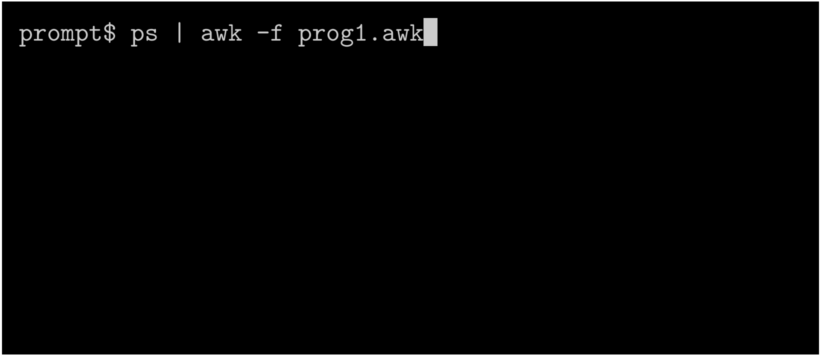

```
prompt$ ps | awk -f prog1.awk
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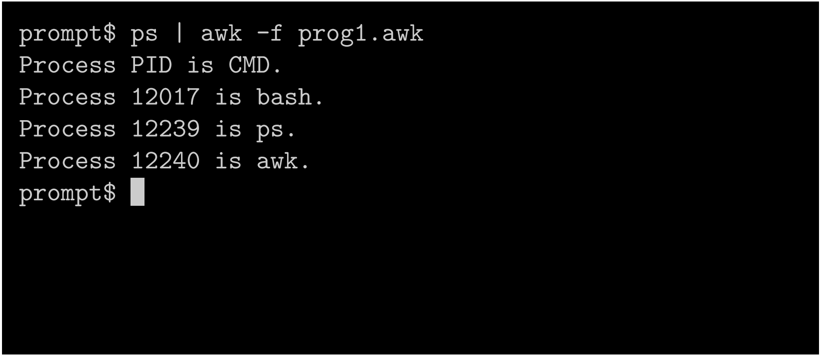
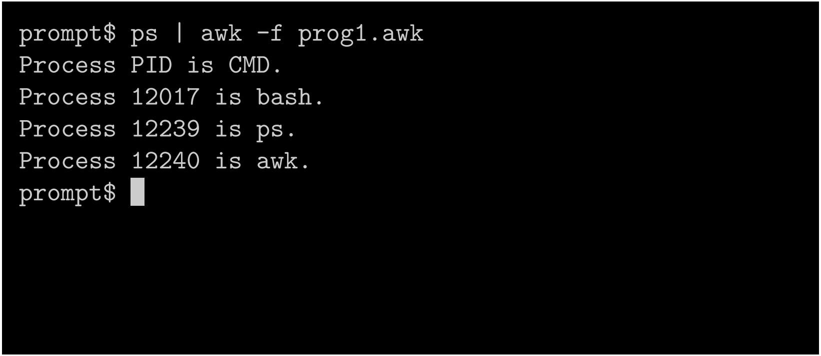


```
prompt$ ps | awk -f prog1.awk
Process PID is CMD.
Process 12017 is bash.
Process 12239 is ps.
Process 12240 is awk.
prompt$ 
```

Using a program file

prog2.awk

```
{ print "Process " $1 " is " $4 "."
  print "    And it is running on terminal " $2
}
```



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prompt$ █
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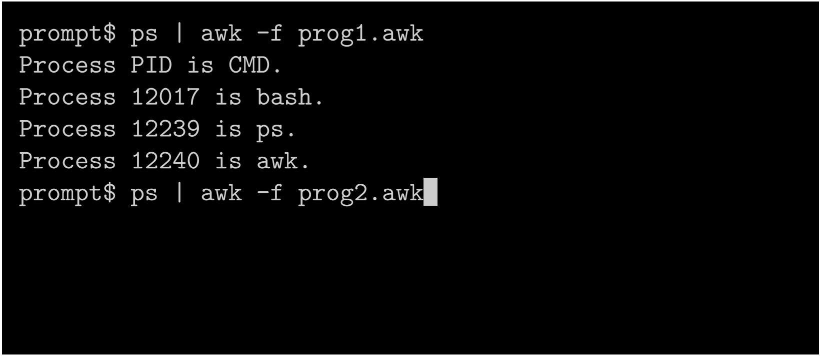

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Process 12017 is bash.
Process 12239 is ps.
Process 12240 is awk.
prompt$ ps | awk -f prog2.awk
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{ print "Process " $1 " is " $4 "."
  print "    And it is running on terminal " $2
}
```

```
prompt$ ps | awk -f prog2.awk
Process PID is CMD.
    And it is running on terminal TTY
Process 12017 is bash.
    And it is running on terminal pts/0
Process 12041 is ps.
    And it is running on terminal pts/0
Process 12042 is awk.
    And it is running on terminal pts/0
prompt$ █
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Ways to specify “which records”

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`BEGIN`

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`END`

- The "virtual record" after the last real record
- For instructions to execute after processing all input
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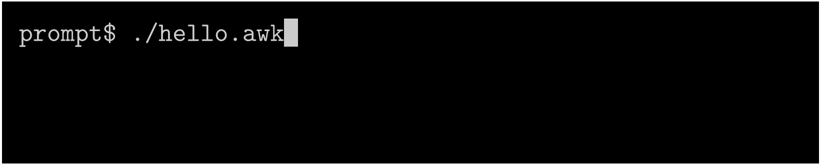

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prompt$ ./hello.awk
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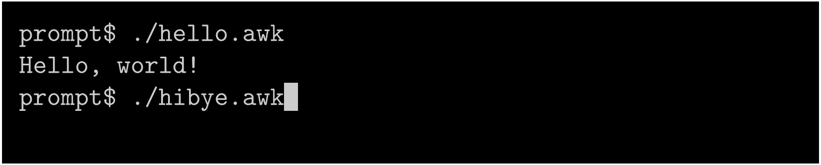

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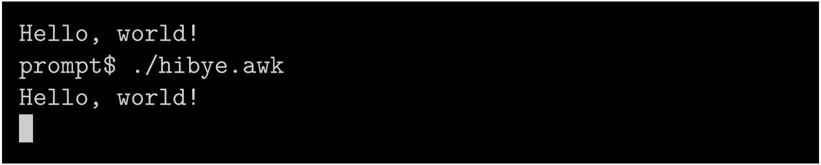

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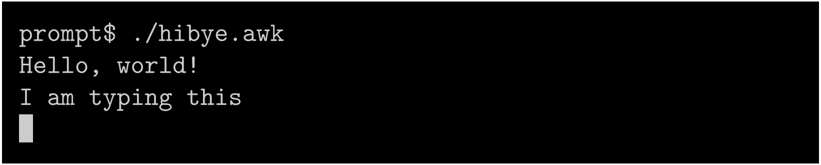

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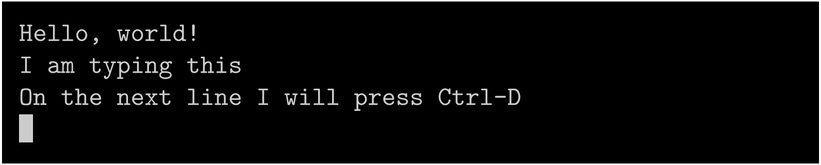

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Goodbye, world!
prompt$ █
```

Matching patterns

`/pattern/`

- Selects records that contain "pattern" somewhere
- Same pattern language as `grep`
  - I.e., "regular expressions"

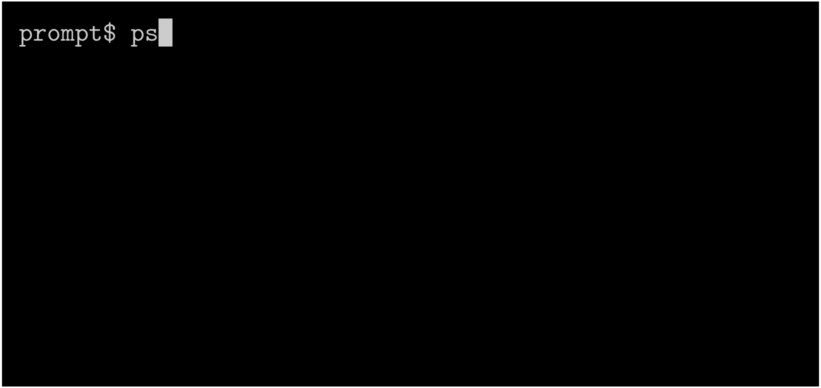
`!/pattern/`

- Selects records that do not contain "pattern"

Example: matching patterns

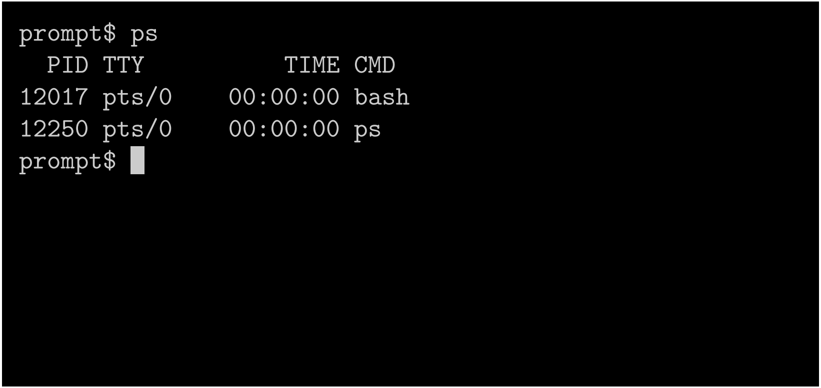
```
prompt$ █
```

Example: matching patterns



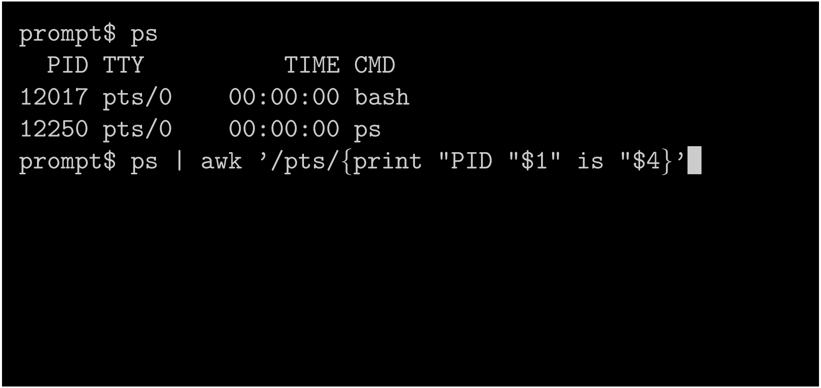
```
prompt$ ps
```

Example: matching patterns



```
prompt$ ps
  PID TTY          TIME CMD
12017 pts/0    00:00:00 bash
12250 pts/0    00:00:00 ps
prompt$ 
```

Example: matching patterns



```
prompt$ ps
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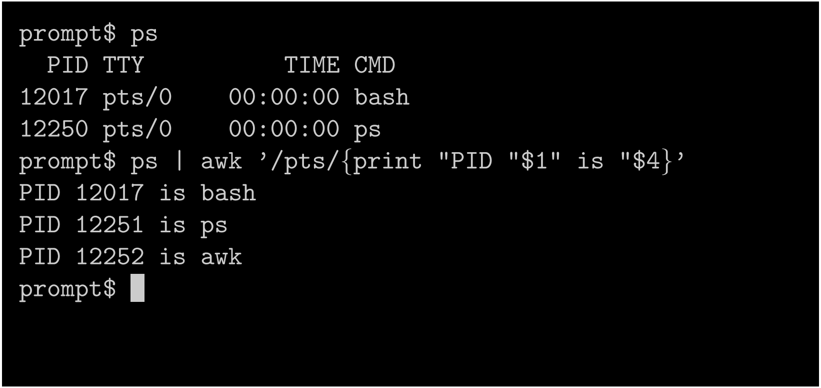
12250 pts/0    00:00:00 ps
prompt$ ps | awk ’/pts/{print "PID "$1" is "$4}’
```

Example: matching patterns



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prompt$ ps
  PID TTY          TIME CMD
12017 pts/0    00:00:00 bash
12250 pts/0    00:00:00 ps
prompt$ ps | awk ’/pts/{print "PID "$1" is "$4}’
PID 12017 is bash
PID 12251 is ps
PID 12252 is awk
prompt$ █
```
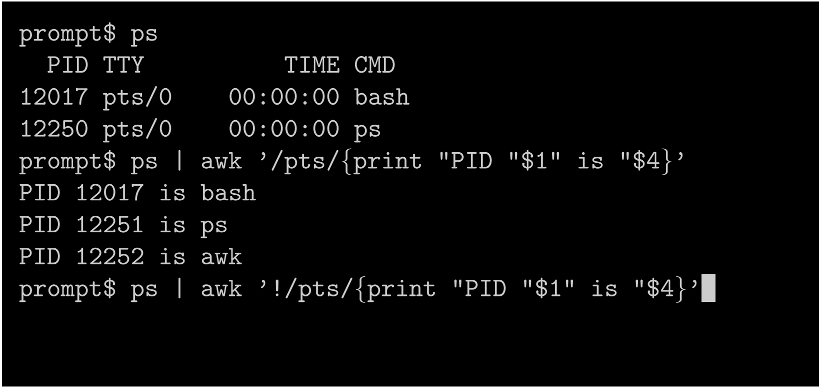
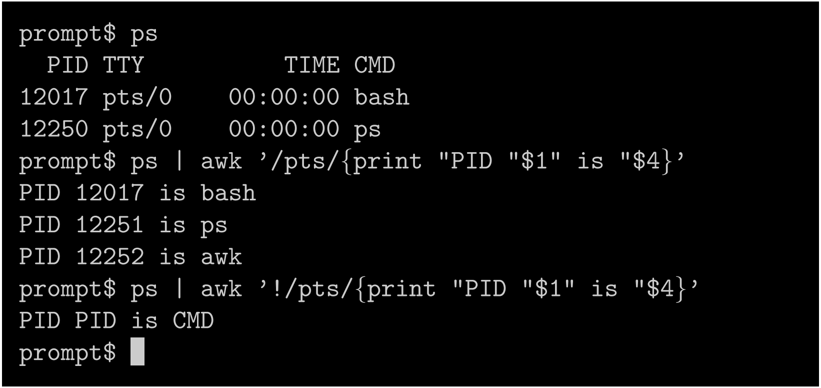

Example: matching patterns



```
prompt$ ps
  PID TTY          TIME CMD
12017 pts/0    00:00:00 bash
12250 pts/0    00:00:00 ps
prompt$ ps | awk ’/pts/{print "PID "$1" is "$4}’
PID 12017 is bash
PID 12251 is ps
PID 12252 is awk
prompt$ ps | awk ’!/pts/{print "PID "$1" is "$4}’
```

Example: matching patterns



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PID PID is CMD
prompt$
```

Simple quiz

What does `awk '/pattern/'` do?

Simple quiz

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awk ’/pattern/’  ≡  awk ’/pattern/{print}’
                 ≡  awk ’/pattern/{print $0}’
```

- Print input lines that contain “pattern”

Simple quiz

What does `awk '/pattern/'` do?

```
awk '/pattern/'  ≡  awk '/pattern/{print}'
                 ≡  awk '/pattern/{print $0}'
```

- Print input lines that contain "pattern"
- `awk '/pattern/'` ≡ `grep 'pattern'`
- `awk '!/pattern/'` ≡ `grep -v 'pattern'`

More ways to select records

relational–expression

- Select records based on the criteria in the expression

What can go in the "relational–expression"?

- Terms
  - Literals: `"Bob"`, `"50"`, `50`
  - Fields: `$4`
  - Variables (in a few slides . . .)
- Relational operators
  - The usual C/Java ones: `>`, `<`, `>=`, `<=`, `==`, `!=`
  - Are clever about string vs. numerical comparisons
- Parentheses for grouping
- Logical operators
  - The usual C/Java ones: `!`, `&&`, `||`

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  - Are clever about string vs. numerical comparisons
- Parentheses for grouping
- Logical operators
  - The usual C/Java ones: `!`, `&&`, `||`
- Matching operators. . .

Matching operators?

What are the matching operators?

str ˜ /pattern/

- Check if string `str` matches `pattern`
- Again, pattern is a regular expression

str !˜ /pattern/

- Check if string `str` does not match `pattern`

Example: prog1.awk revisited

prog1.awk

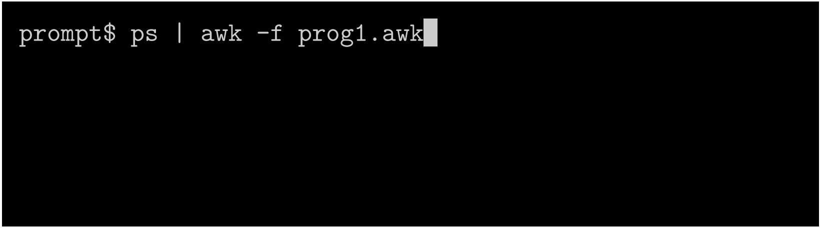
```
{ print "Process " $1 " is " $4 "." }
```

```
prompt$ 
```

Example: prog1.awk revisited

prog1.awk

```
{ print "Process " $1 " is " $4 "." }
```

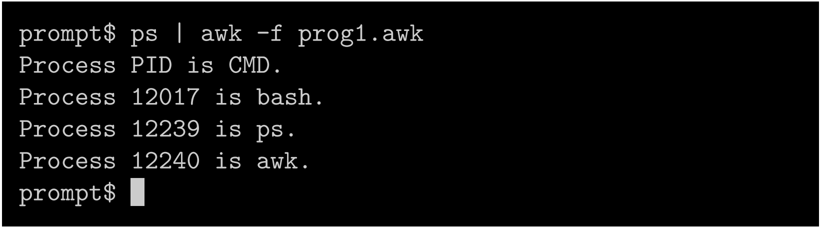


```
prompt$ ps | awk -f prog1.awk
```

Example: prog1.awk revisited

prog1.awk

```
{ print "Process " $1 " is " $4 "." }
```



```
prompt$ ps | awk -f prog1.awk
Process PID is CMD.
Process 12017 is bash.
Process 12239 is ps.
Process 12240 is awk.
prompt$ █
```

Example: prog1.awk revisited

prog1.awk

```
{ print "Process " $1 " is " $4 "." }
```

```
prompt$ ps | awk -f prog1.awk
Process PID is CMD.
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```

- How can we avoid printing “Process PID is CMD”?

Example: prog1.awk revisited

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Process PID is CMD.
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```

- How can we avoid printing “`Process PID is CMD`”?
  - One way — select records where field 1 is not PID

Example: prog1.awk revisited

prog1.awk

```
{ print "Process " $1 " is " $4 "." }
```

```
prompt$ ps | awk -f prog1.awk
Process PID is CMD.
Process 12017 is bash.
Process 12239 is ps.
Process 12240 is awk.
prompt$
```

- How can we avoid printing “Process PID is CMD”?
  - One way — select records where field 1 is not PID

prog3.awk

```
$1 != "PID" { print "Process " $1 " is " $4 "." }
```

Cryptic 1–line example program

```
$3 ~ /bob/ {print $9}
```

Cryptic 1–line example program

```
$3 ~ /bob/ {print $9}
```

- For all records where field 3 matches the pattern /bob/, . . .

Cryptic 1–line example program

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- For all records where field 3 matches the pattern `/bob/`, . . .
- Print field 9

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```
prompt$
```

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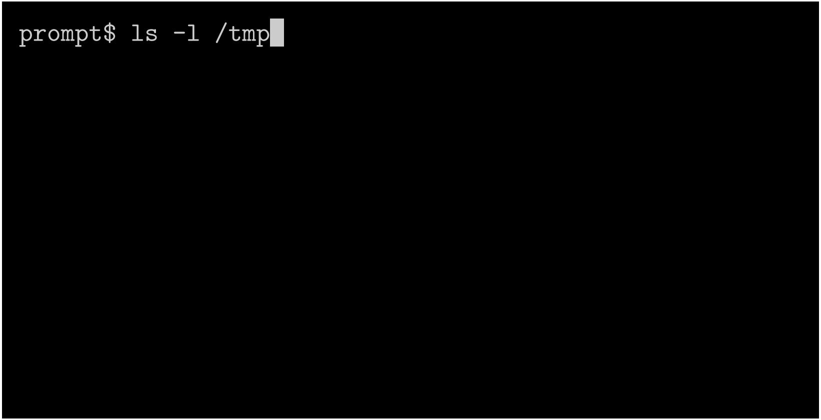

```
prompt$ ls -l /tmp
```

Cryptic 1–line example program

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- For all records where field 3 matches the pattern /bob/, . . .
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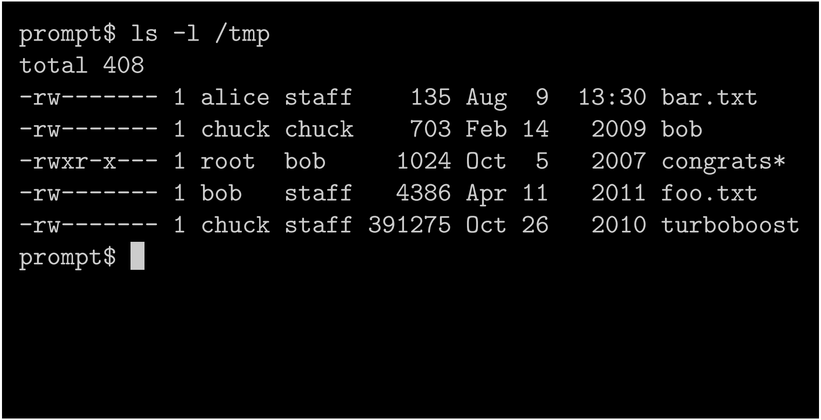

```
prompt$ ls -l /tmp
total 408
-rw------- 1 alice staff    135 Aug  9  13:30 bar.txt
-rw------- 1 chuck chuck    703 Feb 14   2009 bob
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-rw------- 1 bob   staff   4386 Apr 11   2011 foo.txt
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prompt$ █
```

Cryptic 1–line example program

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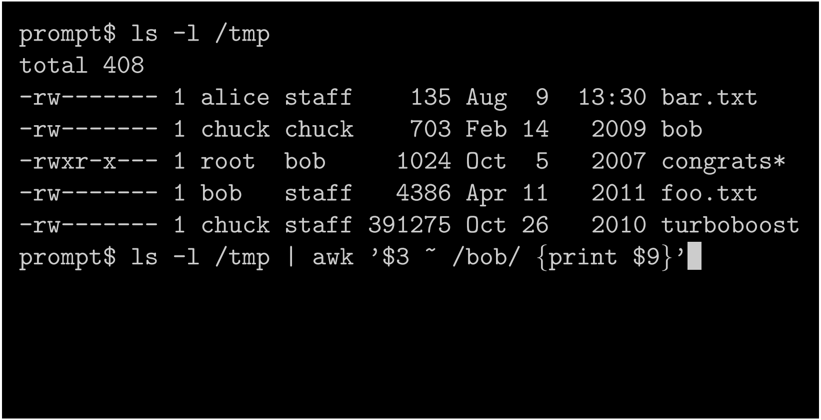

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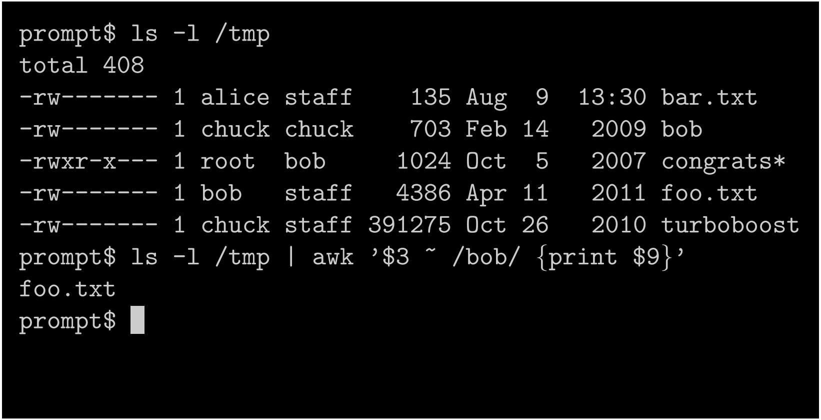

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-rw------- 1 alice staff    135 Aug  9  13:30 bar.txt
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foo.txt
prompt$ 
```

Cryptic 1–line example program

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$3 ~ /bob/ {print $9}
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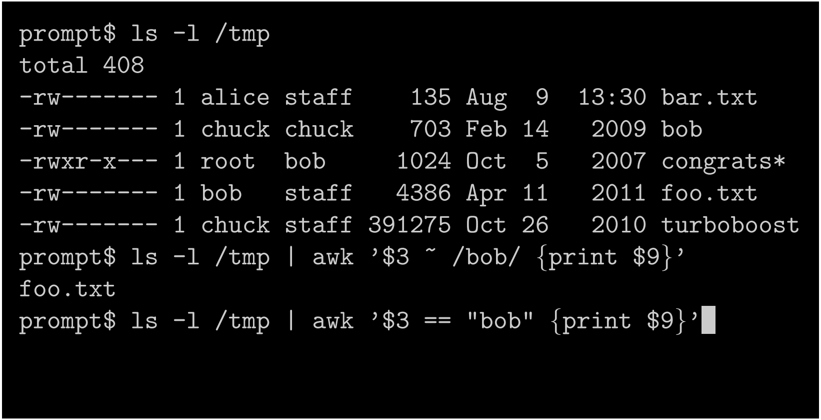

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Cryptic 1–line example program

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- For all records where field 3 matches the pattern /bob/, . . .
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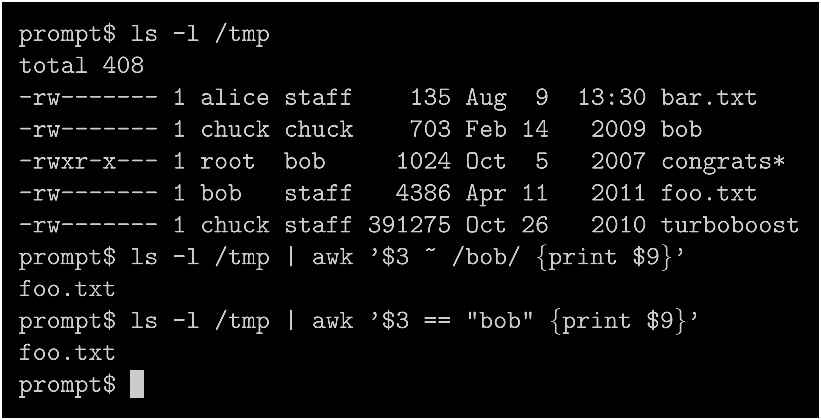

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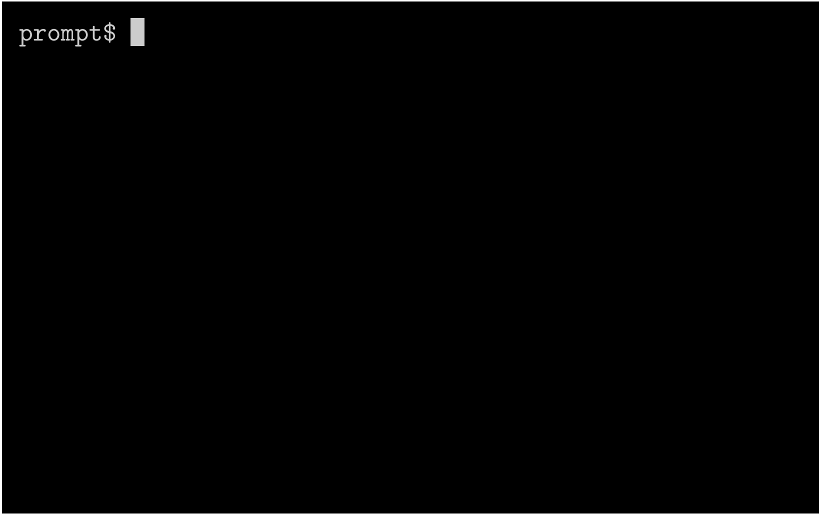

```
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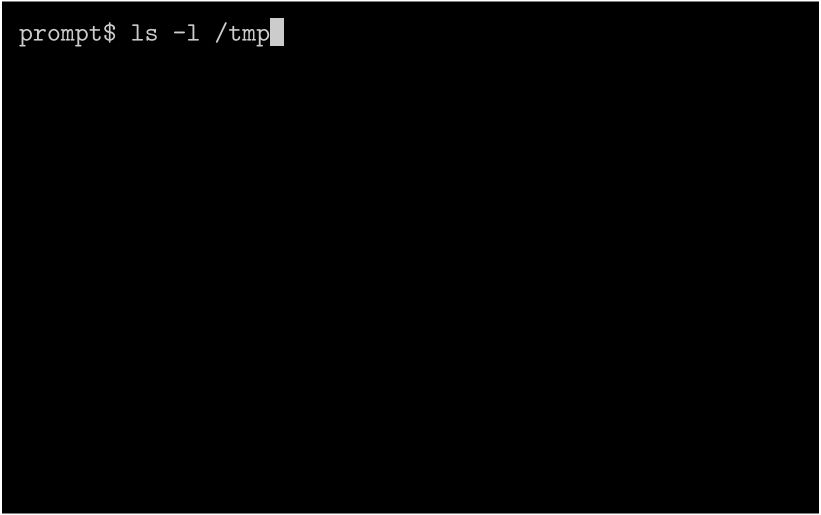

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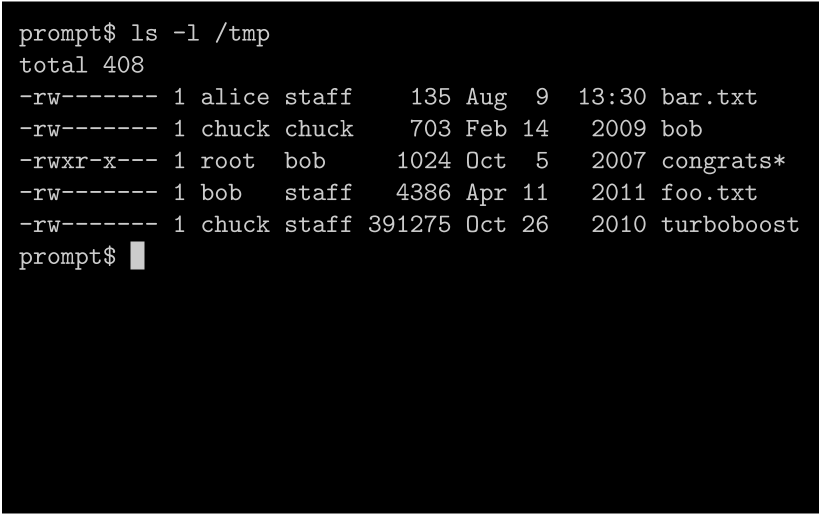

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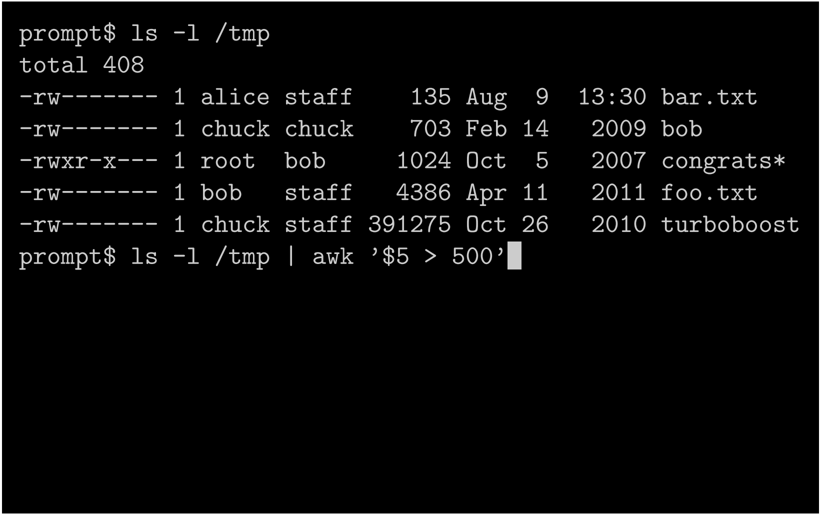

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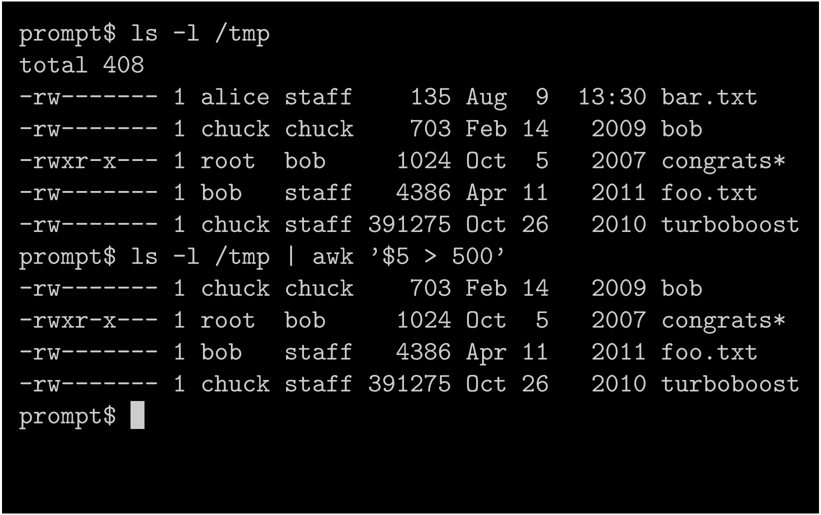

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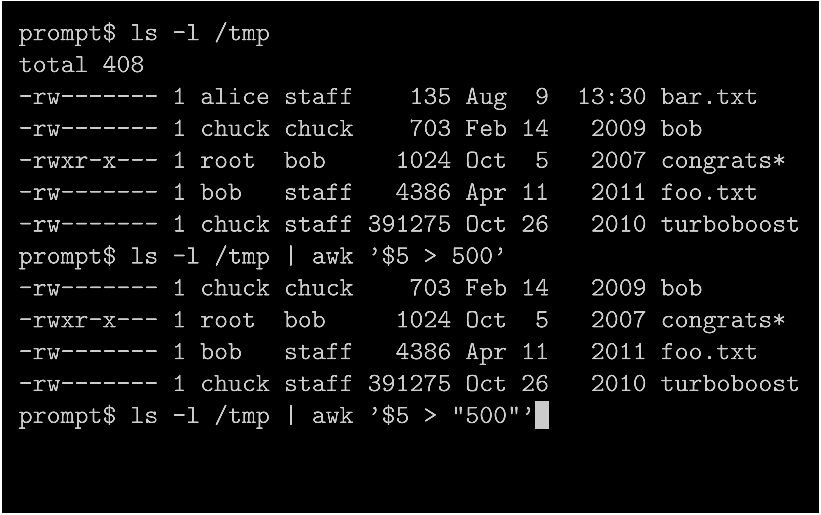

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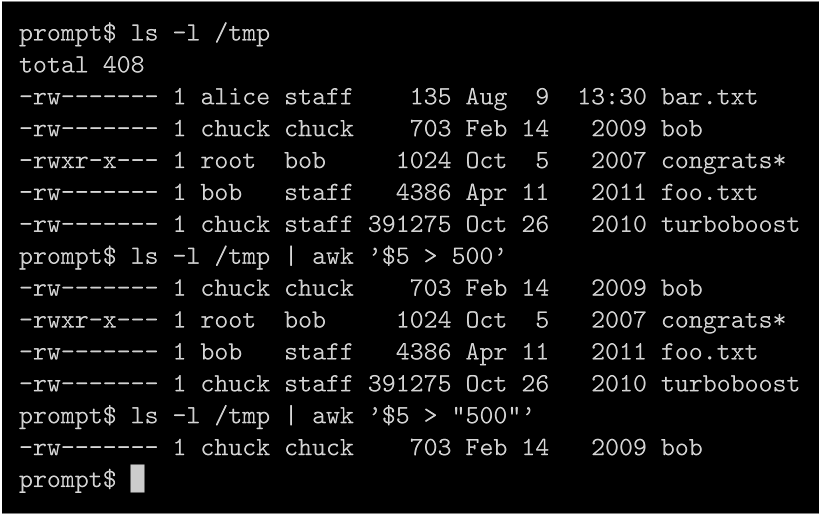

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-rw------- 1 chuck chuck    703 Feb 14   2009 bob
prompt$ █
```

AWK variables

- Same variable naming rules as bash / C / Java
  - May contain letters, digits, underscores
  - May not start with a digit
  - Are case sensitive
- Like bash: no need to declare them
- Like bash: no type information
- Unlike bash: each variable has two values
  - A string value
  - A numeric value
    - Non-numeric strings have numeric value 0
  - `awk` uses the appropriate value based on expression
- Using a variable is like C / Java
  - Do not need the annoying “$” of `bash`

AWK operators

Same as C / Java but some extras

+	addition
−	subtraction or unary minus
∗	multiplication
/	division
%	modulo

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Same as C / Java but some extras

+	addition
−	subtraction or unary minus
*	multiplication
/	division
%	modulo
^	exponentiation
**	exponentiation (not POSIX compliant)

AWK assignment operators

Includes the usual C / Java operators

= Assignment

+= Add value to a variable

-= Subtract value from a variable

*= Multiply variable by a value

/= Divide variable by a value

%= “Mod” variable by a value

^= “Exponentiate” variable by a value

**= “Exponentiate” variable by a value

- Not POSIX compliant

++ Increment operator (pre or post)

-- Decrement operator (pre or post)

Example: display a file with line counts

catn.awk

```
#!/usr/bin/awk -f
```

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```
#!/usr/bin/awk -f
BEGIN  { n = 0 }
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#!/usr/bin/awk -f
BEGIN  { n = 0 }
       { n++; print n ":\t" $0 }
```

Example: display a file with line counts

catn.awk

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#!/usr/bin/awk -f
BEGIN  { n = 0 }
       { print ++n ":\t" $0 }
```

Example: show files owned by bob

With a byte total at the end

We will use

```
ls -l | ./bobtotal.awk
```

Need to write the AWK program `bobtotal.awk`

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`bobtotal.awk`

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#!/usr/bin/awk -f
BEGIN  { total = 0 }
$3 == "bob"  { print; total += $5 }
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Example: show files owned by bob

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Need to write the AWK program `bobtotal.awk`

bobtotal.awk

```
#!/usr/bin/awk -f
BEGIN  { total = 0 }
$3 == "bob"  { print; total += $5 }
END    { print "Total is " total " bytes." }
```

Parameters to AWK programs

- A bit of a hack. . .

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Parameters to AWK programs

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- Variables can be initialized *on the command line*
  - E.g., “`var=value`”
  - Cannot have spaces around equals sign
- Can initialize variables *in between* files
- The `BEGIN` block executes before any arguments are processed

Example: generalizing bobtotal.awk to any user

With a default user of root

We will use something like

```
ls -l | ./total.awk user=bob
```

Need to write the AWK program total.awk

total.awk

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#!/usr/bin/awk -f
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#!/usr/bin/awk -f
BEGIN  { user="root"; total = 0 }
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Need to write the AWK program total.awk

total.awk

```
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BEGIN  { user="root"; total = 0 }
$3 == user  { print; total += $5 }
END    { print "Total is " total " bytes." }
```

AWK “system” variables (1)

NF number of fields in the current record

- Can be changed, but POSIX does not specify behavior

FS field separator

- Can be changed
- Or use command–line switch `-F`
- Default is “space” for “chunk of whitespace”

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Example: print the number of search directories in your `PATH`

```
echo $PATH | awk -F: '{print NF}'
```

AWK “system” variables (2)

FILENAME name of the current input file

FNR total number of records seen in the current input file

NR total number of records seen so far

RS record separator

- Can be changed
- Default is “newline character”

AWK "system" variables (2)

FILENAME name of the current input file

FNR total number of records seen in the current input file

NR total number of records seen so far

RS record separator

- Can be changed
- Default is "newline character"
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AWK "system" variables (2)

FILENAME name of the current input file

FNR total number of records seen in the current input file

NR total number of records seen so far

RS record separator

- Can be changed
- Default is "newline character"
- Can be set to a regular expression

Easy version of `catn`:

catn.awk

```
#!/usr/bin/awk -f
{ print NR ":\t" $0 }
```

Fun use of NR

- How to print the first 17 lines of a file?

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```
head -n 17 file
```

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Fun use of NR

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```
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```

- How to print the first 17 lines of a file, using awk?

```
awk 'NR <= 17' file
```

Fun use of NR

- How to print the first 17 lines of a file?

```
head -n 17 file
```

- How to print the first 17 lines of a file, using awk?

```
awk 'NR <= 17' file
```

- How to print from line 42 onward, using awk?

```
awk 'NR >= 42' file
```

Fun use of NR

- How to print the first 17 lines of a file?

```
head -n 17 file
```

- How to print the first 17 lines of a file, using awk?

```
awk 'NR <= 17' file
```

- How to print from line 42 onward, using awk?

```
awk 'NR >= 42' file
```

- How to print lines 17 through 42, using awk?

Fun use of NR

- How to print the first 17 lines of a file?

```
head -n 17 file
```

- How to print the first 17 lines of a file, using awk?

```
awk ’NR <= 17’ file
```

- How to print from line 42 onward, using awk?

```
awk ’NR >= 42’ file
```

- How to print lines 17 through 42, using awk?

```
awk ’(NR >= 17) && (NR <= 42)’ file
```

Cool Trick #1

When specifying a field $\$n$,

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When specifying a field $\$n$, n can be an expression (with variables)

Cool Trick #1

When specifying a field $n, *n* can be an expression (with variables)

Example: print the *last* word on each line

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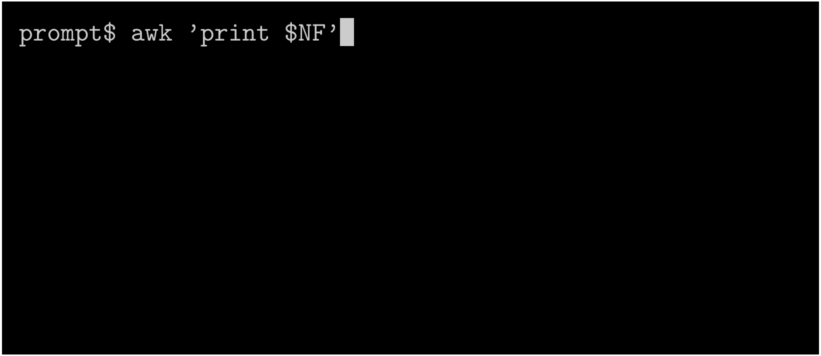

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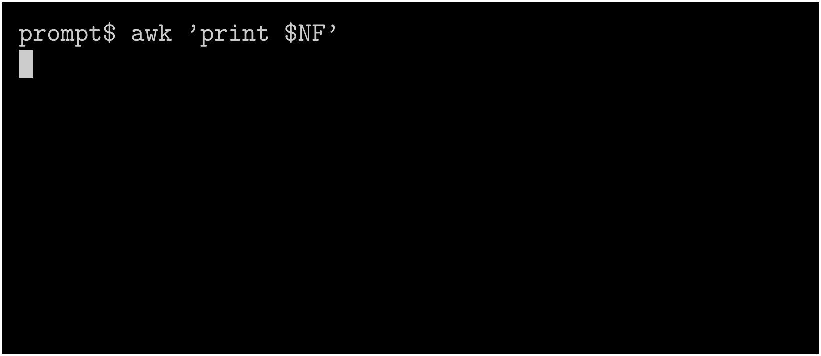

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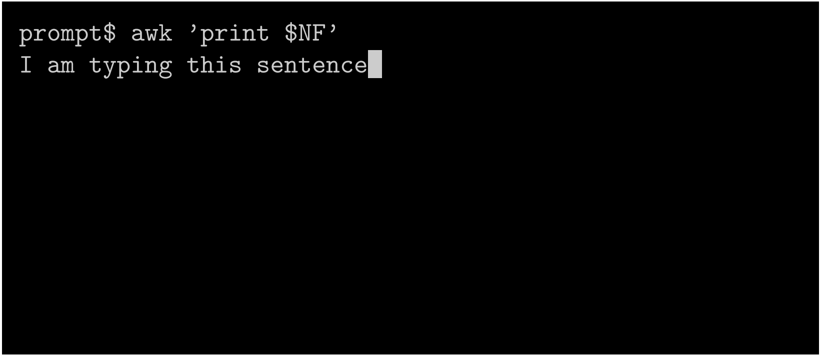

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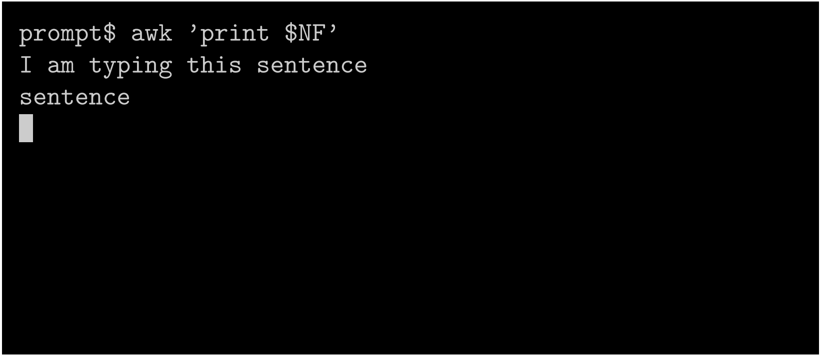

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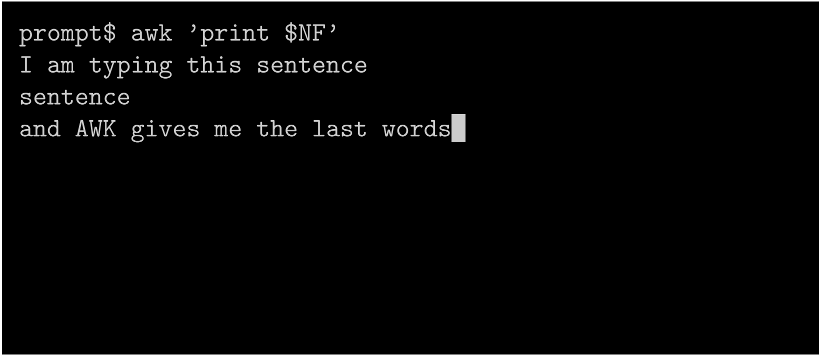

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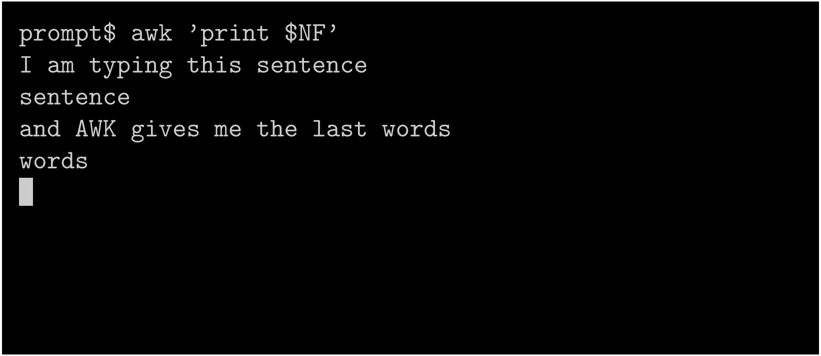

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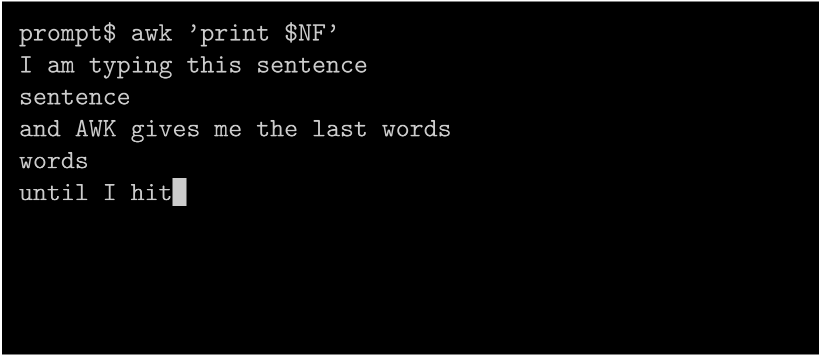

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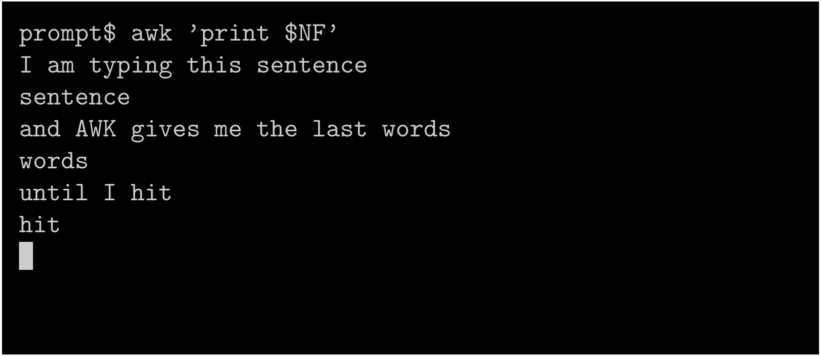

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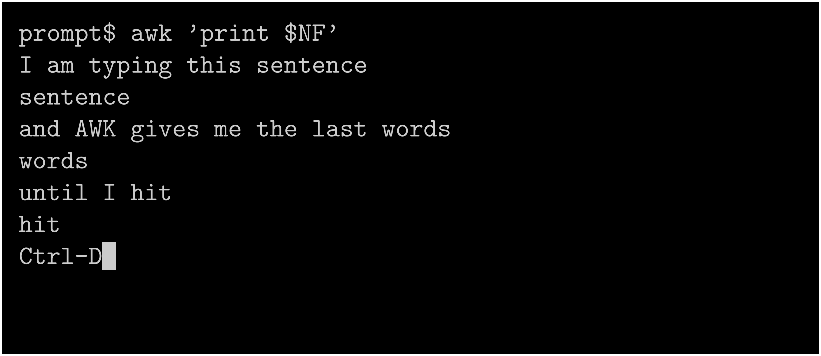

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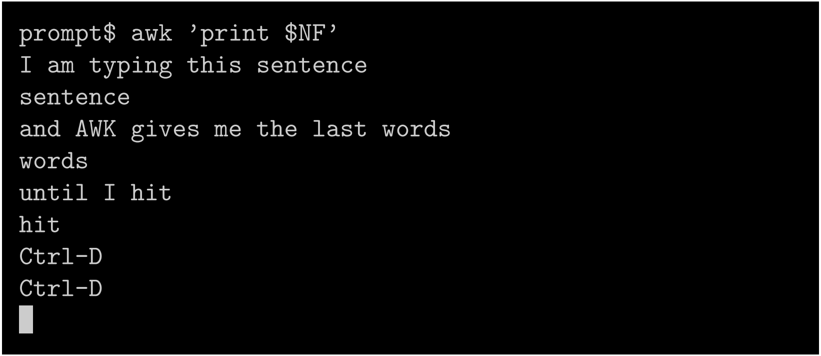

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Cool Trick #2

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- We can assign new values to a field as usual
  - E.g., `$1 = "New thing"`
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- This does change the record in memory
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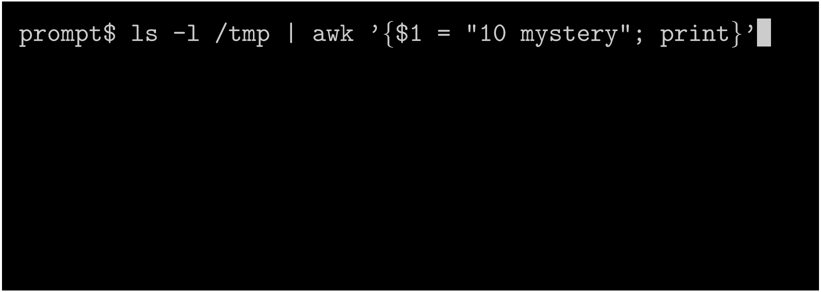

```
prompt$ ls -l /tmp | awk '{$1 = "10 mystery"; print}'
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```
prompt$ ls -l /tmp | awk '{$1 = "10 mystery"; print}'
10 mystery 408
10 mystery 1 alice staff    135 Aug  9  13:30 bar.txt
10 mystery 1 chuck chuck    703 Feb 14   2009 bob
10 mystery 1 root  bob     1024 Oct  5   2007 congrats*
10 mystery 1 bob   staff   4386 Apr 11   2011 foo.txt
10 mystery 1 chuck staff 391275 Oct 26   2010 turboboost
prompt$ █
```

C and AWK

- AWK borrows lots of things from C
  - Kernighan's influence?
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- For example, in AWK we can use:

`printf`

- *Exactly* like in C
- Usage: `printf(` *format-string* [, arg[, arg. . .]])
- See `man 3 printf` for what can go in a format string

Conditionals

- We can use conditionals in the list of instructions
- Syntax is the same as C:

If–then–else syntax

```
if ( Relational-expression )
  instruction-or-block
[ else
  instruction-or-block ]
```

- Can be all on one line, or split
- The `else` part is optional
- “instruction-or-block” is either:
  1. One instruction (may need a semicolon)
  2. Several instructions, grouped in braces

Examples with conditionals

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- Insert a blank line every 5 lines:

```
awk ’{ print; if (!(NR%5)) print ""}’ file
```

  - A zero value means false in AWK (and in C)
  - A non–zero value means true in AWK (and in C)

Conditionals (2)

- We can use the "if-then-else" operator from C

if-then-else operator

```
( Relational-expression ) ? then-expr : else-expr
```

- This goes inside an expression
- The `else` part is required
- Example expressions:

```
(x>1) ? "bob" : "alice"
```

```
2* ( (x>1) ? x : 1 ) + 7
```

Fancy example

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- First line should be bold text
- Remaining lines alternate blue and purple
- Use “escape sequences” to change text style in the terminal
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pretty.awk

```
#!/usr/bin/awk -f
BEGIN       { printf "<bold>" }
{ print $0 ( (NR%2) ? "<blue>" : "<purple>" ) }
END         { printf "<normal>" }
```

Loops

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`commafy.awk`: Convert lists into "," separated lists

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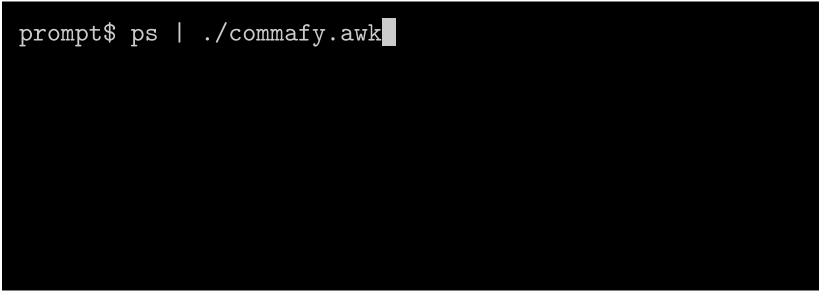

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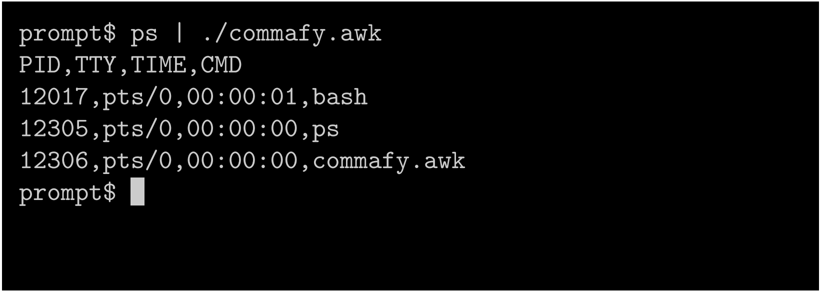

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prompt$ ps | ./commafy.awk
PID,TTY,TIME,CMD
12017,pts/0,00:00:01,bash
12305,pts/0,00:00:00,ps
12306,pts/0,00:00:00,commafy.awk
prompt$ █
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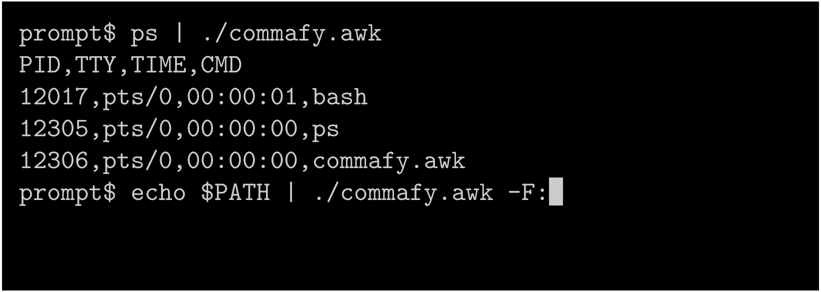

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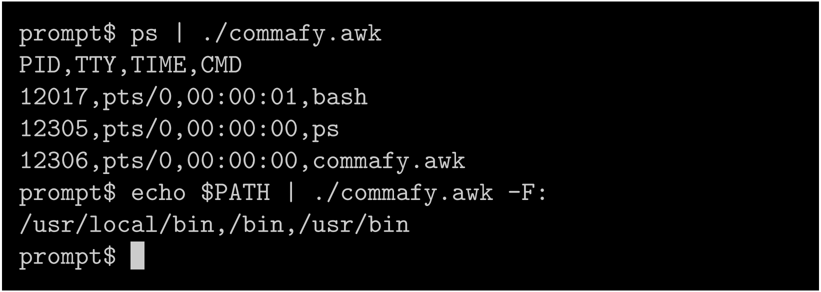

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prompt$ 
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End of lecture