

ForNextDay(14)
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Recursive Factorial $x = 5$

```
(gdb) run
Starting program: /home1/ugrads/scole4/Summer2020/cs2263/lecture/le

Breakpoint 1, 0x000000000400521 in fac ()
(gdb) print $sp
$5 = (void *) 0x7fffffffef220
(gdb) c
Continuing.

Breakpoint 1, 0x000000000400521 in fac ()
(gdb) print $sp
$6 = (void *) 0x7fffffffef1f0
(gdb) c
Continuing.

Breakpoint 1, 0x000000000400521 in fac ()
(gdb) print $sp
$7 = (void *) 0x7fffffffef1c0
(gdb) c
Continuing.

Breakpoint 1, 0x000000000400521 in fac ()
(gdb) print $sp
$8 = (void *) 0x7fffffffef190
(gdb) c
Continuing.

Breakpoint 1, 0x000000000400521 in fac ()
(gdb) print $sp
$9 = (void *) 0x7fffffffef160
(gdb) c
Continuing.

Breakpoint 1, 0x000000000400521 in fac ()
(gdb) print $sp
$10 = (void *) 0x7fffffffef130
(gdb) c
Continuing.
120
[Inferior 1 (process 28291) exited normally]
```

memory: $|0x7fffffffe130 - 0x7fffffffe220| = 0xF0$ or 240

Iterative Factorial $x = 5$

```
(gdb) x/100x $sp
0x7fffffffe220: 0xfffffe250      0x00007fff      0x00400578      0x0
0x7fffffffe230: 0xfffffe338      0x00007fff      0x00400430      0x0
0x7fffffffe240: 0xfffffe330      0x00007fff      0x00000000      0x0
0x7fffffffe250: 0x00000000      0x00000000      0xf7a303d5      0x0
0x7fffffffe260: 0x00000000      0x00000000      0xfffffe338      0x0
0x7fffffffe270: 0x00000000      0x00000001      0x00400558      0x0
0x7fffffffe280: 0x00000000      0x00000000      0x4d561bd3      0x8
0x7fffffffe290: 0x00400430      0x00000000      0xfffffe330      0x0
0x7fffffffe2a0: 0x00000000      0x00000000      0x00000000      0x0
0x7fffffffe2b0: 0x89961bd3      0x7313ab81      0x4a4c1bd3      0x7
0x7fffffffe2c0: 0x00000000      0x00000000      0x00000000      0x0
0x7fffffffe2d0: 0x00000000      0x00000000      0x00000000      0x0
0x7fffffffe2e0: 0x00000000      0x00000000      0x00000000      0x0
0x7fffffffe2f0: 0x00000000      0x00000000      0x00000000      0x0
0x7fffffffe300: 0x00400430      0x00000000      0xfffffe330      0x0
0x7fffffffe310: 0x00000000      0x00000000      0x00400459      0x0
0x7fffffffe320: 0xfffffe328      0x00007fff      0x0000001c      0x0
0x7fffffffe330: 0x00000001      0x00000000      0xfffffe5a1      0x0
0x7fffffffe340: 0x00000000      0x00000000      0xfffffe5df      0x0
0x7fffffffe350: 0xfffffe5f0      0x00007fff      0xfffffe5fc      0x0
0x7fffffffe360: 0xfffffe60b      0x00007fff      0xfffffe625      0x0
0x7fffffffe370: 0xfffffe68b      0x00007fff      0xfffffe6a7      0x0
0x7fffffffe380: 0xfffffe6b7      0x00007fff      0xfffffe6da      0x0
0x7fffffffe390: 0xfffffe70f      0x00007fff      0xfffffe722      0x0
0x7fffffffe3a0: 0xfffffe736      0x00007fff      0xfffffe74b      0x0
```

memory: $|0x7fffffffe3a0 - 0x7fffffffe220| = 0x180$ or 384

Recursive Factorial $x = 10$

```
(gdb) run
Starting program: /home1/ugrads/scole4/Summer2020/cs2263/lecture/lec
Breakpoint 1, 0x0000000000400521 in fac ()
Missing separate debuginfos, use: debuginfo-install glibc-2.17-260.e
(gdb) c
Continuing.

Breakpoint 1, 0x0000000000400521 in fac ()
(gdb) print $sp
$1 = (void *) 0x7fffffffef0
(gdb) c
Continuing.

Breakpoint 1, 0x0000000000400521 in fac ()
(gdb) print $sp
$2 = (void *) 0x7fffffffef0
(gdb) c
Continuing.
```

Breakpoint 1, 0x0000000000400521 in fac ()

(gdb) print \$sp

\$3 = (void *) 0x7fffffffef190

(gdb) print \$sp

\$4 = (void *) 0x7fffffffef190

(gdb) c

Continuing.

Breakpoint 1, 0x0000000000400521 in fac ()

(gdb) print \$sp

\$5 = (void *) 0x7fffffffef160

(gdb) c

Continuing.

Breakpoint 1, 0x0000000000400521 in fac ()

(gdb) print \$sp

\$6 = (void *) 0x7fffffffef130

(gdb) c

Continuing.

Breakpoint 1, 0x0000000000400521 in fac ()

(gdb) print \$sp

\$7 = (void *) 0x7fffffffef100

(gdb) c

Continuing.

Breakpoint 1, 0x0000000000400521 in fac ()

(gdb) print \$sp

\$8 = (void *) 0x7fffffffef0d0

(gdb) c

Continuing.

Breakpoint 1, 0x0000000000400521 in fac ()

(gdb) print \$sp

\$9 = (void *) 0x7fffffffef0a0

(gdb) c

Continuing.

Breakpoint 1, 0x0000000000400521 in fac ()

memory: $|0x7ffffffe040 - 0x7ffffffe1f0| = 0x1B0$ or 432

Iterative Factorial x = 10

```

(gdb) run
Starting program: /home1/ugrads/scole4/Summer2020/cs2263/lecture/le

Breakpoint 1, 0x000000000400521 in fac2 ()
(gdb) x/100x $sp
0x7fffffffef220: 0xfffffe250      0x00007fff      0x00400578      0x00
0x7fffffffef230: 0xfffffe338      0x00007fff      0x00400430      0x00
0x7fffffffef240: 0xfffffe330      0x00007fff      0x00000000      0x00
0x7fffffffef250: 0x00000000      0x00000000      0xf7a303d5      0x00
0x7fffffffef260: 0x00000000      0x00000000      0xfffffe338     0x00
0x7fffffffef270: 0x00000000      0x00000001      0x00400558      0x00
0x7fffffffef280: 0x00000000      0x00000000      0x2fec30fb      0xf
0x7fffffffef290: 0x00400430      0x00000000      0xfffffe330     0x00
0x7fffffffef2a0: 0x00000000      0x00000000      0x00000000      0x00
0x7fffffffef2b0: 0xeb2c30fb      0x0412cf0a      0x28f630fb      0x0
0x7fffffffef2c0: 0x00000000      0x00000000      0x00000000      0x00
0x7fffffffef2d0: 0x00000000      0x00000000      0x00000000      0x00
0x7fffffffef2e0: 0x00000000      0x00000000      0x00000000      0x00
0x7fffffffef2f0: 0x00000000      0x00000000      0x00000000      0x00
0x7fffffffef300: 0x00400430      0x00000000      0xfffffe330     0x00
0x7fffffffef310: 0x00000000      0x00000000      0x00400459      0x00
0x7fffffffef320: 0xfffffe328      0x00007fff      0x0000001c      0x00
0x7fffffffef330: 0x00000001      0x00000000      0xfffffe5a1     0x00
0x7fffffffef340: 0x00000000      0x00000000      0xfffffe5df     0x00
0x7fffffffef350: 0xfffffe5f0      0x00007fff      0xfffffe5fc     0x00
0x7fffffffef360: 0xfffffe60b      0x00007fff      0xfffffe625     0x00
0x7fffffffef370: 0xfffffe68b      0x00007fff      0xfffffe6a7     0x00
0x7fffffffef380: 0xfffffe6b7      0x00007fff      0xfffffe6da     0x00
0x7fffffffef390: 0xfffffe70f      0x00007fff      0xfffffe722     0x00
0x7fffffffef3a0: 0xfffffe736      0x00007fff      0xfffffe74b     0x00
(gdb) print $sp
$1 = (void *) 0x7fffffffef220

```

memory: $|0x7fffffffef3a0 - 0x7fffffffef220| = 0x180$ or 384

Recursive Factorial $x = 15$

```
(gdb) run
```

```
Starting program: /home1/ugrads/scole4/Summer2020/cs2263/lecture/le
```

```
Breakpoint 1, 0x0000000000400521 in fac ()
```

```
Missing separate debuginfos, use: debuginfo-install glibc-2.17-260.
```

```
(gdb) print $sp
```

```
$1 = (void *) 0x7fffffffef220
```

```
(gdb) c
```

```
Continuing.
```

```
Breakpoint 1, 0x0000000000400521 in fac ()
```

```
(gdb) print $sp
```

```
$2 = (void *) 0x7fffffffef1f0
```

```
(gdb) c
```

```
Continuing.
```

```
Breakpoint 1, 0x0000000000400521 in fac ()
```

```
(gdb) print $sp
```

```
$3 = (void *) 0x7fffffffef1c0
```

```
(gdb) c
```

```
Continuing.
```

```
Breakpoint 1, 0x0000000000400521 in fac ()
```

```
(gdb) print $sp
```

```
$4 = (void *) 0x7fffffffef190
```

```
(gdb) c
```

```
Continuing.
```

```
Breakpoint 1, 0x0000000000400521 in fac ()
```

```
(gdb) print $sp
```

```
$5 = (void *) 0x7fffffffef160
```

```
(gdb) c
```

```
Continuing.
```

```
Breakpoint 1, 0x0000000000400521 in fac ()
```

```
(gdb) print $sp
```

```
$6 = (void *) 0x7fffffffef130
```

```
(gdb) c
```

```
Continuing.
```



```
Breakpoint 1, 0x000000000400521 in fac ()
(gdb) print $sp
$7 = (void *) 0x7fffffffef010
(gdb) c
Continuing.

Breakpoint 1, 0x000000000400521 in fac ()
(gdb) print $sp
$8 = (void *) 0x7fffffffdfef0
(gdb) c
Continuing.

Breakpoint 1, 0x000000000400521 in fac ()
(gdb) print $sp
$9 = (void *) 0x7fffffffdfbf0
(gdb) c
Continuing.

Breakpoint 1, 0x000000000400521 in fac ()
(gdb) print $sp
$10 = (void *) 0x7fffffffdf80
(gdb) c
Continuing.

Breakpoint 1, 0x000000000400521 in fac ()
(gdb) print $sp
$11 = (void *) 0x7fffffffdf50
(gdb) c
Continuing.
2004310016
[Inferior 1 (process 29341) exited normally]
```

memory: $|0x7fffffffdf50 - 0x7fffffffef220| = 2D0$ or 720

Iterative Factorial $x = 15$

Starting program: /home1/ugrads/scole4/Summer2020/cs2263/lecture/le

Breakpoint 1, 0x000000000400521 in fac2 ()

(gdb) print \$sp

\$3 = (void *) 0x7fffffffef220

(gdb) x/100x \$sp

0x7fffffffef220:	0xffffef250	0x00007fff	0x00400578	0x0
0x7fffffffef230:	0xffffef338	0x00007fff	0x00400430	0x0
0x7fffffffef240:	0xffffef330	0x00007fff	0x00000000	0x0
0x7fffffffef250:	0x00000000	0x00000000	0xf7a303d5	0x0
0x7fffffffef260:	0x00000000	0x00000000	0xffffef338	0x0
0x7fffffffef270:	0x00000000	0x00000001	0x00400558	0x0
0x7fffffffef280:	0x00000000	0x00000000	0x1c0ca628	0xb
0x7fffffffef290:	0x00400430	0x00000000	0xffffef330	0x0
0x7fffffffef2a0:	0x00000000	0x00000000	0x00000000	0x0
0x7fffffffef2b0:	0xd8cca628	0x4bef6ba1	0x1b16a628	0x4
0x7fffffffef2c0:	0x00000000	0x00000000	0x00000000	0x0
0x7fffffffef2d0:	0x00000000	0x00000000	0x00000000	0x0
0x7fffffffef2e0:	0x00000000	0x00000000	0x00000000	0x0
0x7fffffffef2f0:	0x00000000	0x00000000	0x00000000	0x0
0x7fffffffef300:	0x00400430	0x00000000	0xffffef330	0x0
0x7fffffffef310:	0x00000000	0x00000000	0x00400459	0x0
0x7fffffffef320:	0xffffef328	0x00007fff	0x0000001c	0x0
0x7fffffffef330:	0x00000001	0x00000000	0xffffef5a1	0x0
0x7fffffffef340:	0x00000000	0x00000000	0xffffef5df	0x0
0x7fffffffef350:	0xffffef5f0	0x00007fff	0xffffef5fc	0x0
0x7fffffffef360:	0xffffef60b	0x00007fff	0xffffef625	0x0
0x7fffffffef370:	0xffffef68b	0x00007fff	0xffffef6a7	0x0
0x7fffffffef380:	0xffffef6b7	0x00007fff	0xffffef6da	0x0
0x7fffffffef390:	0xffffef70f	0x00007fff	0xffffef722	0x0
0x7fffffffef3a0:	0xffffef736	0x00007fff	0xffffef74b	0x0

(gdb) c

Continuing.

2004310016

[Inferior 1 (process 29687) exited with code 013]

memory: $|0x7ffffffe3a0 - 0x7ffffffe220| = 0x180$ or 384

I observed the recursive solution increasing in size as more stack frames are created. While the iterative solution grows within a single stack frame.