

Simulating a doctor's waiting room

Goal: Simulate the queuing behavior at a doctor's office.

Assumptions:

- 1 Patients arrive on the minutes between 9:00 am and 11:59 am.
- 2 At most one patient arrives during any minute.
- 3 The probability that a patient arrives in any one minute is 0.075.
- 4 Each patient needs to meet with the doctor for 15 minutes.

Expectations:

- 1 How many patients does the doctor expect to see in the day?
- 2 How much time does the doctor expect to spend with patients?

Simulating this situation: For [

Dealing with the waiting

Integrate the *waiting* aspect of a 'waiting room' into the simulation:

An arriving patient will wait when _____.

Define: $nwait = \# \text{ patients waiting}$
 $endTime = \text{end of patient}$ $busy = \begin{cases} 1 & \text{if doctor busy} \\ 0 & \text{if doctor free} \end{cases}$

Pseudocode:

- ▶ Zero out the counters.
- ▶ For i from 0 up to 180,
 - ▶ If the doctor is finishing with a patient at time i , then set $busy=0$.
 - ▶ Determine if a new patient arrives (random, probability 0.075).
If so, set $newPatient$ to 1; otherwise set $newPatient$ to 0.
 - ▶ If $newPatient == 1$, add one to the number waiting ($nwait++$)
 - ▶ If the doctor is not busy AND there is a patient waiting,
 - ▶ Subtract one from the number waiting ($nwait--$)
 - ▶ Set the doctor to be busy ($busy = 1$)
 - ▶ Set the time when the doctor is not busy to $i + 15$.

Dealing with the waiting

```
nwait = 0; busy = 0; endTime = 0;
For[i = 0, i < 180, i++,
  If[endTime == i, busy = 0];
  newPatient = If[RandomReal[] <= 0.075, 1, 0];
  If[newPatient == 1, nwait++];
  If[busy == 0 && nwait > 0,
    nwait--; busy = 1; endTime = i + 15];
]
```

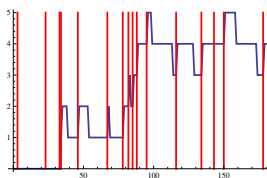
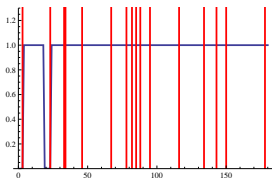
- ▶ For i from 0 up to 180,
 - ▶ If the doctor is finishing with a patient at time i , then set `busy=0`.
 - ▶ Determine if a new patient arrives (random, probability 0.075).
If so, set `newPatient` to 1; otherwise set `newPatient` to 0.
 - ▶ If `newPatient == 1`, add one to the number waiting (`nwait++`)
 - ▶ If the doctor is not busy AND there is a patient waiting,
 - ▶ Subtract one from the number waiting (`nwait--`)
 - ▶ Set the doctor to be busy (`busy = 1`)
 - ▶ Set the time when the doctor is not busy to $i + 15$.

What does the simulation tell us?

We did the simulation, but what was the point?

- ▶ How much of the day will the doctor will be busy?
- ▶ What is the average number of patients in the waiting room?
- ▶ How many people are in the waiting room at noon?
- ▶ How late will the doctor stay after noon?

What statistics do we need to keep track of to answer these questions?



This is just one instance; the power of simulation comes from running the model many times and understanding the average behavior.

Gathering data

- ▶ How many people are in the waiting room at noon?

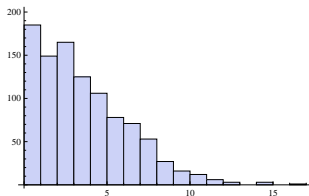
```
nwait = 0; busy = 0; endTime = 0;
For[i = 0, i < 180, i++,
  If[endTime == i, busy = 0];
  newPatient = If[RandomReal[] <= 0.075, 1, 0];
  If[newPatient == 1, nwait++];
  If[busy == 0 && nwait > 0,
    nwait--; busy = 1; endTime = i + 15];
];
nwait ← [Outputs the value after the loop ends.]
```

Running many trials

- ▶ How many people are in the waiting room at noon?

Simulate 1000 times using a Table command, generate a histogram.

```
trials = Table[
nwait = 0; busy = 0; endTime = 0;
For[i = 0, i < 180, i++,
  If[endTime == i, busy = 0];
  newPatient = If[RandomReal[] <= 0.075, 1, 0];
  If[newPatient == 1, nwait++];
  If[busy == 0 && nwait > 0,
    nwait--; busy = 1; endTime = i + 15];
];
nwait ], {j,1000}]
Mean[trials] ← [Average: 3.105]
Histogram[trials]
```



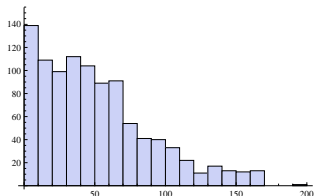
Gathering data

- ▶ How late will the doctor stay after noon?

```
nwait = 0; busy = 0; endTime = 0;
For[i = 0, i < 180, i++,
  If[endTime == i, busy = 0];
  newPatient = If[RandomReal[] <= 0.075, 1, 0];
  If[newPatient == 1, nwait++];
  If[busy == 0 && nwait > 0,
    nwait--; busy = 1; endTime = i + 15];
];
```

↑ [*How to calculate how long
the doctor has to stay after noon?*]

Mean: 51 minutes (does this make sense?)

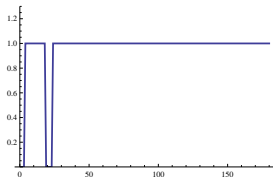


Gathering and plotting time-dependent data

- How much of the day will the doctor will be busy?

Keep track of if the doctor is busy by using a variable `isBusy`.

```
nwait = 0; busy = 0; endTime = 0;
For[i = 0, i < 180, i++,
  If[endTime == i, busy = 0];
  newPatient = If[RandomReal[] <= 0.075, 1, 0];
  If[newPatient == 1, nwait++];
  If[busy == 0 && nwait > 0,
    nwait--; busy = 1; endTime = i + 15];
  isBusy[i]=busy; ← [this copies busy into isBusy[i].]
];          ↓ [Puts data into a list.]
busyList=Table[isBusy[i],i,0,179]
Total[busyList] ← [Total time busy.]
ListLinePlot[busyList]
```



Gathering and plotting time-dependent data

- What is the average number of patients in the waiting room?

Keep track of number of waiting patients by using a variable numWait.

```
nwait = 0; busy = 0; endTime = 0;
For[i = 0, i < 180, i++,
  If[endTime == i, busy = 0];
  newPatient = If[RandomReal[] <= 0.075, 1, 0];
  If[newPatient == 1, nwait++];
  If[busy == 0 && nwait > 0,
    nwait--; busy = 1; endTime = i + 15];
  numWait[i]=nwait; ← [this copies nwait into numWait[i].]
];           ↓ [Puts data into a list.]
waitList=Table[numWait[i],i,0,179]
m=Mean[waitList] ← [Average patients.]
p1=ListLinePlot[waitList];
p2=Plot[m,x,0,179];
Show[p1,p2]
```

