- Previous Lecture:
  - Branching
  - Logical operators
- Today's Lecture:
  - Logical operators and values
  - More branching—*nesting*
  - The idea of repetition
- Announcement:
  - Project 1 (P1) due today at 6pm
  - Please register your clicker by Monday 2/4

"Truth table"

X, Y represent boolean expressions.
E.g., d>3.14

X	Y	X && Y "and"	X || Y "or"	~y "not"
T	T	T	T	F
T	F	F	T	T
F	T	F	T	F
F	F	F	F	T

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Logical operators

&& logical and: Are both conditions true?
E.g., we ask "is $L \le x_c$ and $x_c \le R$?"
In our code: `L<=xc && xc<=R`

|| logical or: Is at least one condition true?
E.g., we can ask if x_c is outside of $[L,R]$,
i.e., "is $x_c \le L$ or $R \le x_c$?"
In code: `xc<=L || R<=xc`

~ logical not: Negation
E.g., we can ask if x_c is not outside $[L,R]$.
In code: `~(xc<=L || R<=xc)`

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Logical operators will short-circuit

- "It's a good thing."
- Consider the compound condition
  `L<=xc && xc<=R`
- If `L` is greater than `xc`, then the 1st condition⇒*false*. Then the entire compound condition must give *false* as well, no matter what `xc` and `R` are.
- A && condition short-circuits to false if the left operand evaluates to *false*
- A || condition short-circuits to _________ if
  ______________________________________.

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Always use logical operators to connect simple boolean expressions

Why is it wrong to use the expression
`L <= xc <= R`
for checking if x_c is in $[L,R]$?

Example: Suppose `L` is 5, `R` is 8, and `xc` is 10. We know that 10 is not in [5,8], but the expression `L <= xc <= R` gives...

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"Truth table"

Matlab uses **0** to represent false,
1 to represent true

X	Y	X && Y "and"	X || Y "or"	~X "not"
1	1	1	1	0
1	0	0	1	
0	1	0	1	1
0	0	0	0	

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Variables a, b, and c have whole number values. True or false: This fragment prints "Yes" if there is a right triangle with side lengths a, b, and c and prints "No" otherwise.

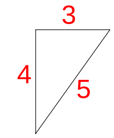
```
if a^2 + b^2 == c^2
   disp('Yes')
else
   disp('No')
end
```

A: true

B: false


```
a = 5;
b = 3;
c = 4;
if  (a^2+b^2==c^2)

   disp('Yes')
else
   disp('No')
end
```

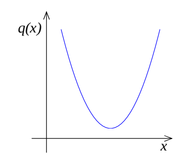


This fragment prints "No" even though we have a right triangle!


```
a = 5;
b = 3;
c = 4;
if ((a^2+b^2==c^2) || (a^2+c^2==b^2)...
                   || (b^2+c^2==a^2))
   disp('Yes')
else
   disp('No')
end
```


Consider the quadratic function

$$q(x) = x^2 + bx + c$$



on the interval $[L , R]$:

- Is the function strictly increasing in $[L , R]$?
- Which is smaller, $q(L)$ or $q(R)$?
- What is the minimum value of $q(x)$ in $[L , R]$?

Conclusion

If x_c is between L and R

Then min is at x_c

Otherwise

Min value is at one of the endpoints

Start with pseudocode

If *xc* is between *L* and *R*

Min is at *xc*

Otherwise

Min is at one of the endpoints

We have decomposed the problem into three pieces! Can choose to work with any piece next: the if-else construct/condition, min at xc, or min at an endpoint

Set up structure first: if-else, condition

```
if  L<=xc && xc<=R

    Then min is at xc

else

    Min is at one of the endpoints

end
```

Now refine our solution-in-progress. I'll choose to work on the if-branch next

Refinement: filled in detail for task "min at xc"

```
if  L<=xc && xc<=R
   % min is at xc
   qMin= xc^2 + b*xc + c;

else

   Min is at one of the endpoints

end
```

Continue with refining the solution… else-branch next

Refinement: detail for task "min at an endpoint"

```
if  L<=xc && xc<=R
   % min is at xc
   qMin= xc^2 + b*xc + c;
else
   % min is at one of the endpoints
   if  %xc left of bracket
      %min is at L
   else  %xc right of bracket
      %min is at R
   end
end
```

Continue with the refinement, i.e., replace comments with code

Refinement: detail for task "min at an endpoint"

```
if  L<=xc && xc<=R
   % min is at xc
   qMin= xc^2 + b*xc + c;
else
   % min is at one of the endpoints
   if  xc < L
      qMin= L^2 + b*L + c;
   else
      qMin= R^2 + b*R + c;
   end
end
```

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Final solution (given b,c,L,R,xc)

```
if  L<=xc && xc<=R
   % min is at xc
   qMin= xc^2 + b*xc + c;
else
   % min is at one of the endpoints
   if  xc < L
      qMin= L^2 + b*L + c;
   else
      qMin= R^2 + b*R + c;
   end
end
```

An if-statement can appear within a branch—just like any other kind of statement!

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Notice that there are 3 alternatives→can use elseif!

```
if  L<=xc && xc<=R
   % min is at xc
   qMin= xc^2 + b*xc + c;
else
   % min is at one of the endpoints
   if  xc < L
      qMin= L^2 + b*L + c;
   else
      qMin= R^2 + b*R + c;
   end
end
```

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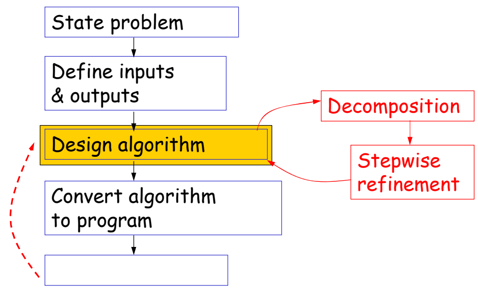
```
if  L<=xc && xc<=R
   % min is at xc
   qMin= xc^2 + b*xc + c;
elseif xc < L
   qMin= L^2 + b*L + c;
else
   qMin= R^2 + b*R + c;
end
```

True or false: We don't need the **elseif** keyword at all (in the Matlab language).

A: true

B: false

Top-Down Design



An algorithm is an idea. To use an algorithm you must choose a programming language and implement the algorithm.

If xc is between L and R
Then min value is at xc

Otherwise
Min value is at one of the endpoints


```
if  L<=xc && xc<=R
   % min is at xc

else
   % min is at one of the endpoints



end
```



```
if  L<=xc && xc<=R
   % min is at xc

else
   % min is at one of the endpoints



end
```



```
if  L<=xc && xc<=R
   % min is at xc
   qMin= xc^2 + b*xc + c;
else
   % min is at one of the endpoints



end
```

```
if  L<=xc && xc<=R
   % min is at xc
   qMin= xc^2 + b*xc + c;
else
   % min is at one of the endpoints



end
```

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```
if  L<=xc && xc<=R
   % min is at xc
   qMin= xc^2 + b*xc + c;
else
   % min is at one of the endpoints
   if  xc < L

   else

   end
end
```

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```
if  L<=xc && xc<=R
   % min is at xc
   qMin= xc^2 + b*xc + c;
else
   % min is at one of the endpoints
   if  xc < L
      qMin= L^2 + b*L + c;
   else
      qMin= R^2 + b*R + c;
   end
end
```

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Question

A stick of unit length is split into two pieces. The breakpoint is randomly selected. On average, how long is the shorter piece?

Physical experiment?
Thought experiment? → analysis
Computational experiment! → simulation

Need to repeat many trials!

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