- Previous Lecture (and Discussion):
  - Branching (`if`, `elseif`, `else`, `end`)
  - Relational operators (<, >=, ==, ~=, …, etc.)
- Today's Lecture:
  - Logical operators (&&, ||, ~) and "short-circuiting"
  - More branching—*nesting*
  - Top-down design
- Announcements:
  - Project 1 (P1) due Thursday at 11pm
  - Submit real .m files (plain text, not from a word processing software such as Microsoft Word)
  - Register your clicker using the link on the course website

Lecture 4 1

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 $[L , R]$?

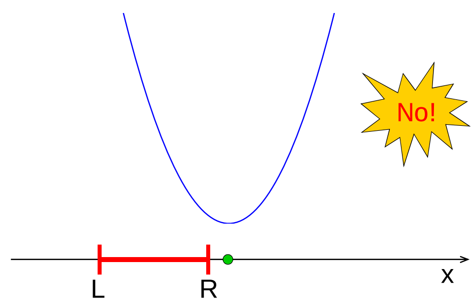
Lecture 4 4

Modified Problem 3

Write a code fragment that prints "yes" if xc is in the interval and "no" if it is not.

Lecture 4 6

$$q(x) = x^2 + bx + c \qquad x_c = -b/2$$



Lecture 4 7

So what is the requirement?

```
% Determine whether xc is in
% [L,R]
xc = -b/2;

if ________________

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

Lecture 4 10

The value of a boolean expression is either true or false.

```
(L<=xc) && (xc<=R)
```

This (compound) boolean expression is made up of two (simple) boolean expressions. Each has a value that is either true or false.

Connect boolean expressions by boolean operators:

and	or	not
&&	||	~

Lecture 4 12

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 $x_c < L$ or $R < x_c$?"

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)`

"Truth table"

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

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

Logical operators "short-circuit"

a > b && c > d
true — Go on

a > b && c > d
false — Stop

Entire expression is false since the first part is false

A **&&** expression short-circuits to false if the left operand evaluates to *false*.

A **||** expression short-circuits to ________________ if ____

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…

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.

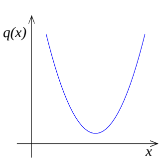
```
if a^2 + b^2 == c^2
   disp('Yes')
else
   disp('No')
end
```

A: true

B: false

Consider the quadratic function

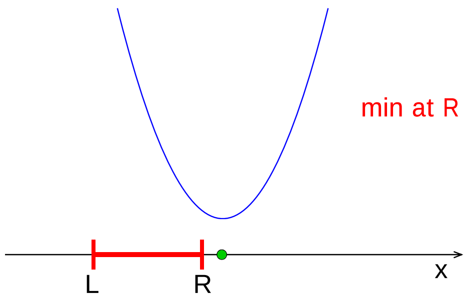
$$q(x) = x^2 + bx + c$$



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 $[L , R]$?

$$q(x) = x^2 + bx + c \qquad x_c = -b/2$$



Lecture 4 34

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

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!

See `quadMin.m` `quadMinGraph.m`

Lecture 4 43

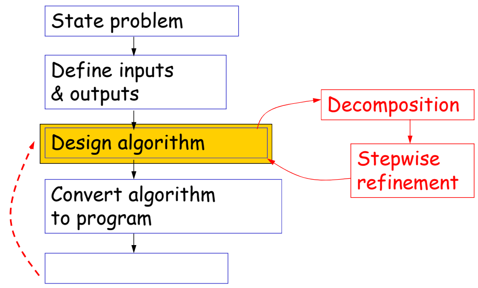
Notice that there are 3 alternatives→can use elseif!

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

```
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
```

Lecture 4 44

Top-Down Design



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

Lecture 4 48

Does this program work?

```
score= input('Enter score: ');
if score>55
     disp('D')
elseif score>65
     disp('C')
elseif score>80
     disp('B')
elseif score>93
     disp('A')
else
     disp('Not good…')
end
```

A: yes

B: no

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