Branches and Loops

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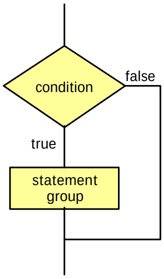
Branches

- Branches are used to select and execute specific sections of the code while skipping other sections
- Selection of different sections depend on a condition statement
- We will learn:
  - if statement
  - switch statement

Branches: “if” Statement



if (condition),
    statement 1
    statement 2
    …
end

statement group

Branches: “if” Statement

- Conditions can be:
  - any real value (0 is false, non-zero is true)
  - combination of relational and logical operators
    - e.g. (x > 0) & (x < 10)
  - logical functions
    - isempty()
    - isnumeric(), ischar()
    - isinf(), isnan()
    - exist()

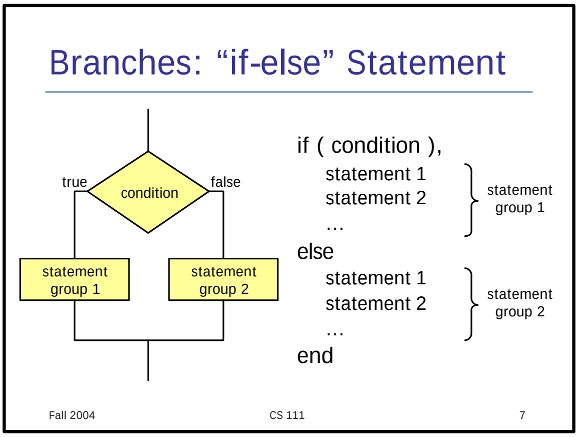
Branching Examples

- Examples:
  - if (r <= 0),
        disp(‘Radius must be positive’);
    end
  - if ((grade < 0) | (grade > 100)),
        disp(‘Grade must be in [0,100] range’);
    end
  - if isinf(result),
        disp(‘Result is infinite’);
    end

Branching Examples

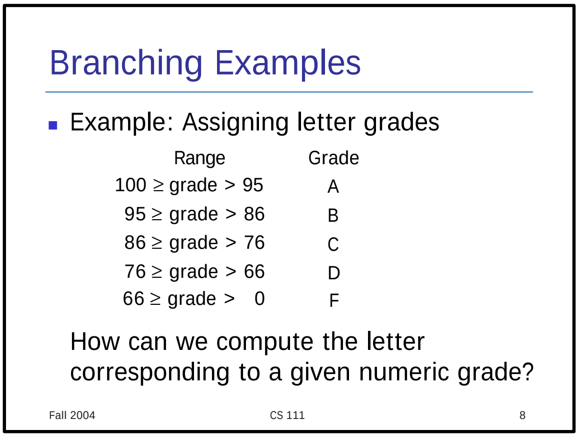
- Water tank example:

```
r = input('Enter the radius of the tank base (in meters):');
if ( r <= 0 ),
    error( ‘Radius must be positive' );
end
h = input('Enter the height of the tank (in meters):');
if ( h <= 0 ),
    error( ‘Height must be positive' );
end
w = input('Enter the amount of water (in m3):');
if ( w <= 0 ),
    error( ‘Amount of water must be positive' );
end
capacity = pi * r^2 * h;
space = capacity - w;
if ( space > 0 ),
    disp( [ 'There is ' num2str(space) ' m3 extra space' ] );
else
    disp( 'Tank is full' );
end
```



Branches: “if-else” Statement

```
if ( condition ),
    statement 1
    statement 2        } statement group 1
    …
else
    statement 1
    statement 2        } statement group 2
    …
end
```

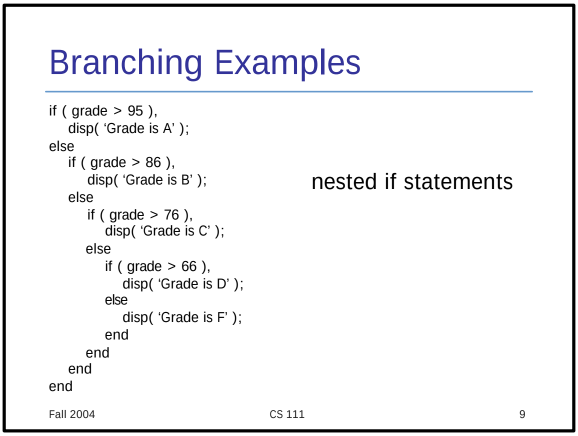


Branching Examples

- Example: Assigning letter grades

Range	Grade
100 ≥ grade > 95	A
95 ≥ grade > 86	B
86 ≥ grade > 76	C
76 ≥ grade > 66	D
66 ≥ grade > 0	F

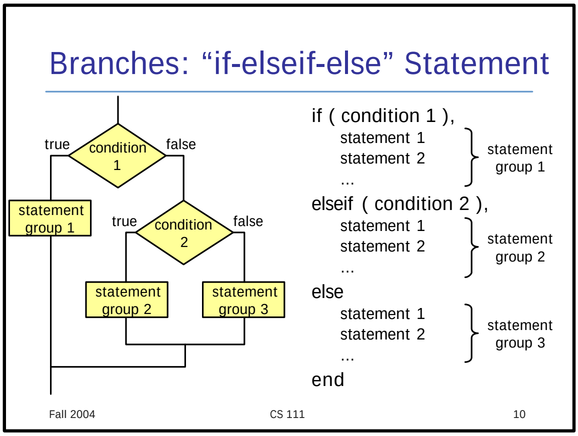
How can we compute the letter corresponding to a given numeric grade?



Branching Examples

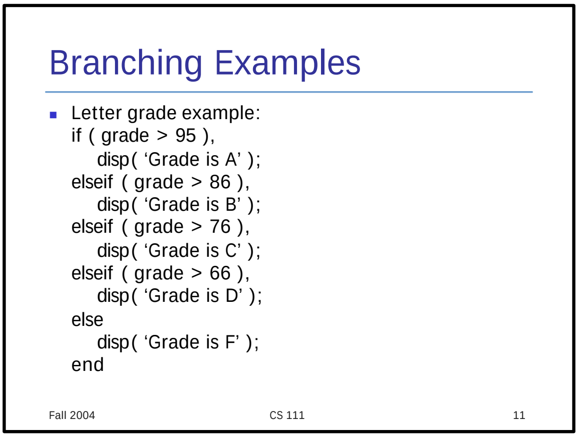
```
if ( grade > 95 ),
    disp( ‘Grade is A’ );
else
    if ( grade > 86 ),
        disp( ‘Grade is B’ );
    else
        if ( grade > 76 ),
            disp( ‘Grade is C’ );
        else
            if ( grade > 66 ),
                disp( ‘Grade is D’ );
            else
                disp( ‘Grade is F’ );
            end
        end
    end
end
```

nested if statements



Branches: “if-elseif-else” Statement

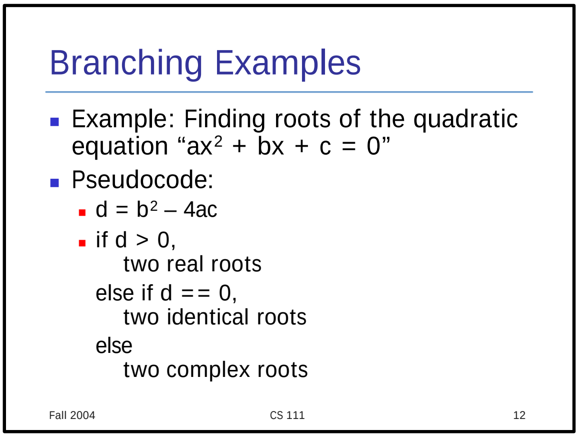
```
if ( condition 1 ),
    statement 1
    statement 2        } statement group 1
    …
elseif ( condition 2 ),
    statement 1
    statement 2        } statement group 2
    …
else
    statement 1
    statement 2        } statement group 3
    …
end
```



Branching Examples

- Letter grade example:

```
if ( grade > 95 ),
    disp( ‘Grade is A’ );
elseif ( grade > 86 ),
    disp( ‘Grade is B’ );
elseif ( grade > 76 ),
    disp( ‘Grade is C’ );
elseif ( grade > 66 ),
    disp( ‘Grade is D’ );
else
    disp( ‘Grade is F’ );
end
```



Branching Examples

- Example: Finding roots of the quadratic equation “$ax^2 + bx + c = 0$”
- Pseudocode:

```
- $d = b^2 – 4ac$
- if $d > 0$,
      two real roots
  else if $d == 0$,
      two identical roots
  else
      two complex roots
```

Branching Examples

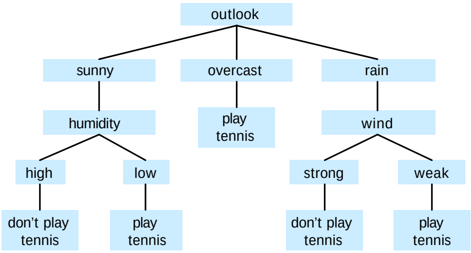
```
% Prompt the user for the coefficients of the equation
disp ('This program solves for the roots of a quadratic ');
disp ('equation of the form A*X^2 + B*X + C = 0. ');
a = input ('Enter the coefficient A: ');
b = input ('Enter the coefficient B: ');
c = input ('Enter the coefficient C: ');

% Calculate discriminant
discriminant = b^2 - 4 * a * c;

% Solve for the roots, depending on the value of the discriminant
if discriminant > 0 % there are two real roots, so...
   x1 = ( -b + sqrt(discriminant) ) / ( 2 * a );
   x2 = ( -b - sqrt(discriminant) ) / ( 2 * a );
   disp ('This equation has two real roots:');
   fprintf ('x1 = %f\n', x1);
   fprintf ('x2 = %f\n', x2);
elseif discriminant == 0  % there is one repeated root, so...
   x1 = ( -b ) / ( 2 * a );
   disp ('This equation has two identical real roots:');
   fprintf ('x1 = x2 = %f\n', x1);
else % there are complex roots, so ...
   real_part = ( -b ) / ( 2 * a );
   imag_part = sqrt ( abs ( discriminant ) ) / ( 2 * a );
   disp ('This equation has complex roots:');
   fprintf('x1 = %f +i %f\n', real_part, imag_part );
   fprintf('x2 = %f -i %f\n', real_part, imag_part );
end
```

Branching Examples

- Example: Decision for playing tennis



Branching Examples

```
outlook = input( ‘How is the outlook? (o)vercast, (s)unny, (r)ainy: ‘, ‘s’ );
if ( outlook == ‘o’ ),
   disp( ‘You can play tennis’ );
elseif ( outlook == ‘s’ ),
   humidity = input( ‘How is humidity? (h)igh, (l)ow: ‘, ‘s’ );
   if ( humidity == ‘h’ ),
      disp(‘I do not recommend you play tennis’ );
   elseif ( humidity == ‘l’ ),
      disp( ‘You can play tennis’ );
   else
      disp( ‘Invalid humidity info’ );
   end
elseif ( outlook == ‘r’ ),
   wind = input( ‘How is the wind? (s)trong, (w)eak: ‘, ‘s’ );
   if ( wind == ‘s’ ),
      disp( ‘I do not recommend you play tennis’ );
   elseif (wind == ‘w’ ),
      disp( ‘You can play tennis’ );
   else
      disp( ‘Invalid wind info’ );
   end
else
   disp( ‘Invalid outlook info’ );
end
```

Branching Examples

```
outlook = input( ‘How is the outlook? (o)vercast, (s)unny, (r)ainy: ‘, ‘s’ );
if ( outlook == ‘o’ ),
disp( ‘You can play tennis’ );
elseif (outlook == ‘s’),
humidity = input( ‘How is humidity? (h)igh, (l)ow: ‘, ‘s’ );
if ( humidity == ‘h’ ),
disp(‘I do not recommend you play tennis’ );
elseif ( humidity == ‘l’ ),
disp( ‘You can play tennis’ );
else
disp( ‘Invalid humidity info’ );
end
elseif ( outlook == ‘r’ ),
wind = input( ‘How is the wind? (s)trong, (w)eak: ‘, ‘s’ );
if ( wind == ‘s’ ),
disp( ‘I do not recommend you play tennis’ );
elseif (wind == ‘w’ ),
disp( ‘You can play tennis’ );
else
disp( ‘Invalid wind info’ );
end
else
disp( ‘Invalid outlook info’ );
end
```

indentation is important
for understandability

Branches: “switch” Statement

```
switch ( expression ),
case value 1,
    statement 1
    statement 2
    …
case value 2,
    statement 1
    statement 2
    …
…
end
```

← expression is a scalar or string constant

} statement group 1

} statement group 2

Branches: “switch” Statement

```
switch ( expression ),
case {value set 1},
   statement 1
   statement 2
   …
case {value set 2},
   statement 1
   statement 2
   …
…
otherwise,
   statement 1
   statement 2
   …
end
```

} statement group 1

} statement group 2

} optional statement group that is executed if none of the cases is satisfied

Branching Examples

- Example: Odd or even numbers

```
switch (value),
case {1,3,5,7,9},
    disp( ‘Odd number’ );
case {2,4,6,8,10},
    disp( ‘Even number’ );
otherwise,
    disp( ‘Out of range’ );
end
```

Branching Examples

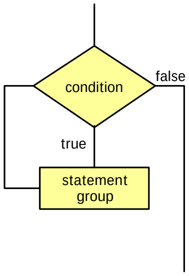
- Example: Unit converter

```
x = input( ‘length (in cm): ‘ );
u = input( ‘unit: ‘, ‘s’ );
switch (u),
case { ‘cm’, ’centimeter’ },
    disp( [ num2str(x) ‘cm’ ] );
case { ‘mm’, ’millimeter’ },
    disp( [ num2str(10*x) ‘mm’ ] );
case { ‘m’, ’meter’ },
    disp( [ num2str(x/100) ‘m’ ] );
case { ‘in’, ’inch’ },
    disp( [ num2str(2.54*x) ‘in’ ] );
otherwise,
    disp( ‘Unknown unit’ );
end
```

Loops

- Loops are used to execute a sequence of statements more than once
- We will learn:
  - while loop
  - for loop
- They differ in how the repetition is controlled

Loops: “while” Loop



- Statements are executed indefinitely as long as the condition is satisfied

```
while ( condition ),
    statement 1  }
    statement 2  } statement group
    ...          }
end
```

Loop Examples

- Example: Arithmetic mean and standard deviation of non-negative measurements
- Pseudocode:

```
Initialize sum_x, sum_x2, n
Read first value, x
while x >= 0,
    n ← n + 1
    sum_x ← sum_x + x
    sum_x2 ← sum_x2 + x^2
    Read next value, x
end
x_mean ← sum_x / n
x_std ← sqrt( ( n * sum_x2 – sum_x^2 ) / ( n * (n-1) ) )
Display results to the user
```

Loop Examples

```
% Initialize sums.
n = 0; sum_x = 0; sum_x2 = 0;

% Read in first value
x = input('Enter first value: ');

% While Loop to read input values.
while x >= 0

   % Accumulate sums.
   n      = n + 1;
   sum_x  = sum_x + x;
   sum_x2 = sum_x2 + x^2;

   % Read in next value
   x = input('Enter next value:  ');

end

% Calculate the mean and standard deviation
x_bar = sum_x / n;
std_dev = sqrt( (n * sum_x2 - sum_x^2) / (n * (n-1)) );

% Tell user.
fprintf('The mean of this data set is: %f\n', x_bar);
fprintf('The standard deviation is:    %f\n', std_dev);
fprintf('The number of data points is: %f\n', n);
```

Loops: “for” Loop

- Statements are executed a specified number of times

```
for index = expression,
    statement 1  }
    statement 2  } statement group
    ...          }
end
```

- Expression is usually a vector in shortcut notation first:increment:last

Loop Examples

- Example:

```
for x = 1:2:10,
    x
end
```

- Output:

```
x =
     1
x =
     3
x =
     5
x =
     7
x =
     9
```

Loop Examples

- Example:

```
for x = [ 1 5 13 ],
    x
end
```

- Output:

```
x =
     1
x =
     5
x =
     13
```

Loop Examples

- Example:

```
for x = [ 1 2 3; 4 5 6 ],
    x
end
```

- Output:

```
x =
     1
     4
x =
     2
     5
x =
     3
     6
```

Loop Examples

- Example: Factorial (n!) of an integer n

```
n = input( ‘Please enter n: ‘ );
if ( ( n < 0 ) | ( fix(n) ~= n ) ),
    error( ‘n must be a non-negative integer’ );
end
if ( ( n == 0 ) | ( n == 1 ) ),
    f = 1;
else
    f = 1;
    for ii = 2:n,
        f = f * ii;
    end
end
```

Loop Examples

- Example: Arithmetic mean and standard deviation of non-negative measurements
- Pseudocode:

```
- Initialize sum_x, sum_x2
- Read the number of measurements, n
- for ii = 1:n,
      Read value, x
      sum_x ← sum_x + x
      sum_x2 ← sum_x2 + x^2
  end
- x_mean ← sum_x / n
- x_std ← sqrt( ( n * sum_x2 – sum_x^2 ) / ( n * (n-1) ) )
- Display results to the user
```

Loop Examples

```
% Initialize sums.
sum_x = 0; sum_x2 = 0;

% Get the number of points to input.
n = input('Enter number of points: ');

% Check to see if we have enough input data.
if n < 2   % Insufficient data

   disp ('At least 2 values must be entered.');

else % we will have enough data, so let's get it.

   % Loop to read input values.
   for ii = 1:n
      % Read in next value
      x = input('Enter value:  ');
      % Accumulate sums.
      sum_x  = sum_x + x;
      sum_x2 = sum_x2 + x^2;
   end

   % Now calculate statistics.
   x_bar = sum_x / n;
   std_dev = sqrt( (n * sum_x2 - sum_x^2) / (n * (n-1)) );

   % Tell user.
   fprintf('The mean of this data set is: %f\n', x_bar);
   fprintf('The standard deviation is:    %f\n', std_dev);
   fprintf('The number of data points is: %f\n', n);

end
```

Loop Examples

- Example: Guessing a number computer picks between 1 and 10
- Pseudocode:

```
Pick a random number, num, in [1,10]
Read user's guess
while ( guess ~= num ),
    Read user's new guess
end
```

Loop Examples

```
num = round( (10-1) * rand + 1 );
guess = input( 'Your guess?' );
tries = 1;
while ( guess ~= num ),
   guess = input( 'Your guess?' );
   tries = tries + 1;
end
fprintf( 'You guessed correctly in %d tries', tries );
```

Loop Examples

- Number guessing example: User has only 3 tries
- Pseudocode:

```
Pick a random number, num, in [1,10]
Read user's guess
Initialize number of tries to 1
while ( ( guess ~= num ) & ( tries < 3 ) ),
    Read user's new guess
    Increment number of tries
end
```

Loop Examples

```
num = round( (10-1) * rand + 1 );
guess = input( 'Your guess?' );
tries = 1;
while ( ( guess ~= num ) & ( tries < 3 ) ),
   guess = input( 'Your guess?' );
   tries = tries + 1;
end
if ( guess == num ),
   disp( 'Congratulations!' );
else
   disp( 'You could not guess correctly' );
end
```

Loop Examples

- Example: Nested loops

```
for ii = 1:3,
   for jj = 1:5,
      p = ii * jj;
      fprintf( '%d x %d = %d\n', ii, jj, p );
   end
end
```

Loops: “break/continue” Statements

- Break statement terminates the execution of a loop and passes the control to the next statement after the end of the loop
- Continue statement terminates the current pass through the loop and returns control to the top of the loop

Loop Examples

- Example:

```
for ii = 1:5,
    if ( ii == 3 ),
        break;
    end
    fprintf( 'ii = %d\n', ii );
end
disp( 'End of loop' );
```

- Output:

```
ii = 1
ii = 2
End of loop
```

Loop Examples

- Example:

```
for ii = 1:5,
    if ( ii == 3 ),
        continue;
    end
    fprintf( 'ii = %d\n', ii );
end
disp( 'End of loop' );
```

- Output:

```
ii = 1
ii = 2
ii = 4
ii = 5
End of loop
```

Loop Examples

- Number guessing example: User has only 3 tries
- Pseudocode:
  - Pick a random number, num, in [1,10]
  - for tries = 1:3,

```
for tries = 1:3,
    Read user’s new guess
    Stop if guess is correct
end
```

Loop Examples

```
num = round( (10-1) * rand + 1 );
for tries = 1:3,
    guess = input( 'Your guess?' );
    if ( guess == num ),
        disp( 'Congratulations!' );
        break;
    end
end
if ( guess ~= num ),
    disp( 'You could not guess correctly' );
end
```

Advice

- Use indentation to improve the readability of your code
- Never modify the value of a loop index inside the loop
- Allocate all arrays used in a loop before executing the loop
- If it is possible to implement a calculation either with a loop or using vectors, always use vectors
- Use built-in MATLAB functions as much as possible instead of reimplementing them