Options

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Options

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Option types are used in this situation: t option

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Often, we either have a thing …. or we don't:

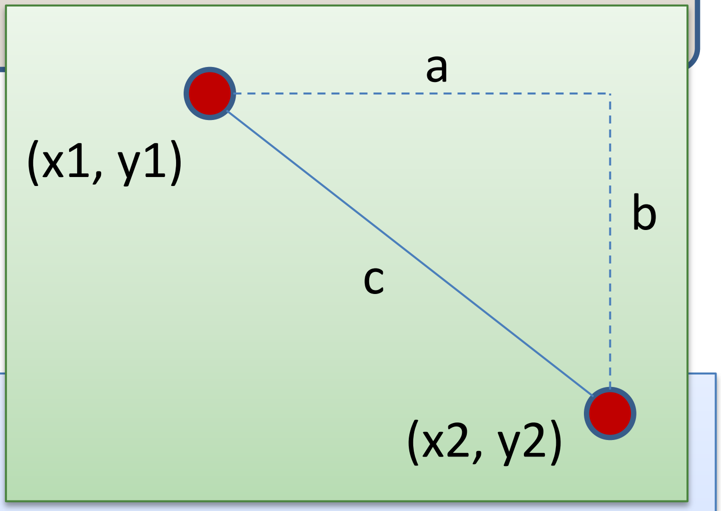
17 “hi”

Option types are used in this situation: t option

There's *one way* to build a pair, but *two ways* to build an optional value:

- None -- when we've got nothing
- Some v -- when we've got a value v of type t

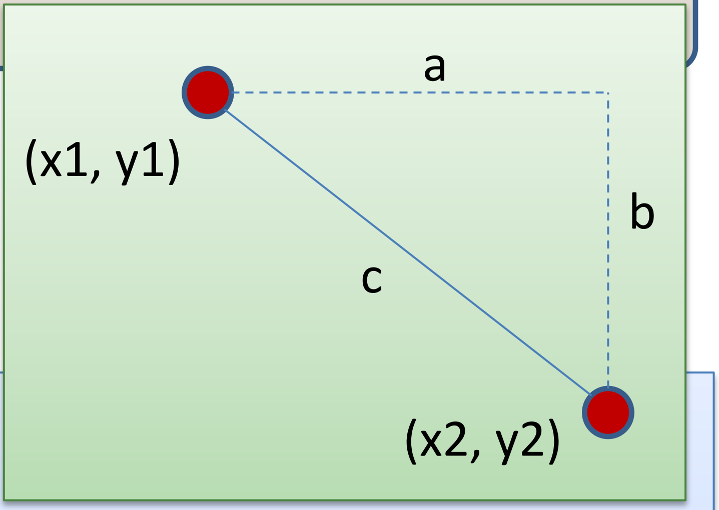
Slope between two points



```
type point = float * float

let slope (p1:point) (p2:point) : float =
```

Slope between two points

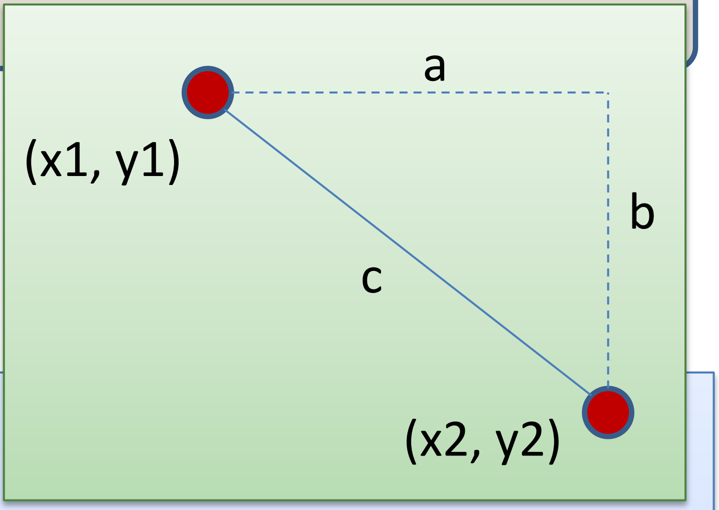


```
type point = float * float

let slope (p1:point) (p2:point) : float =
  let (x1,y1) = p1 in
  let (x2,y2) = p2 in
```

deconstruct tuple

Slope between two points



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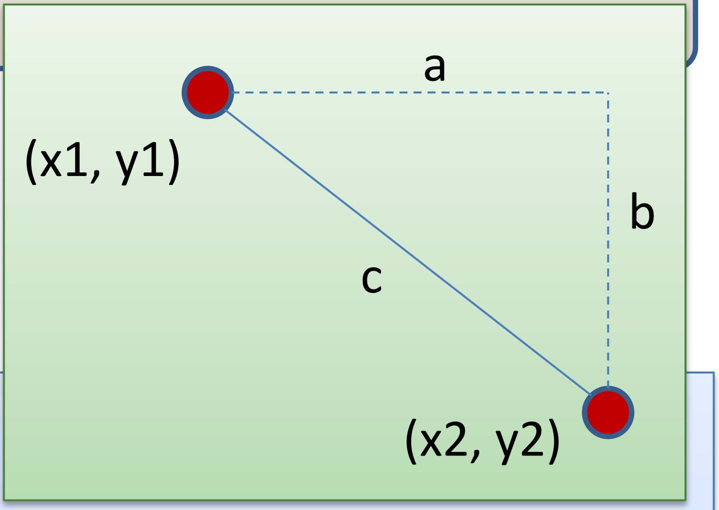
type point = float * float

let slope (p1:point) (p2:point) : float =
  let (x1,y1) = p1 in
  let (x2,y2) = p2 in
  let xd = x2 -. x1 in
  if xd != 0.0 then
    (y2 -. y1) /. xd
  else
    ???
```

avoid divide by zero

what can we return?

Slope between two points



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type point = float * float

let slope (p1:point) (p2:point) : float option =
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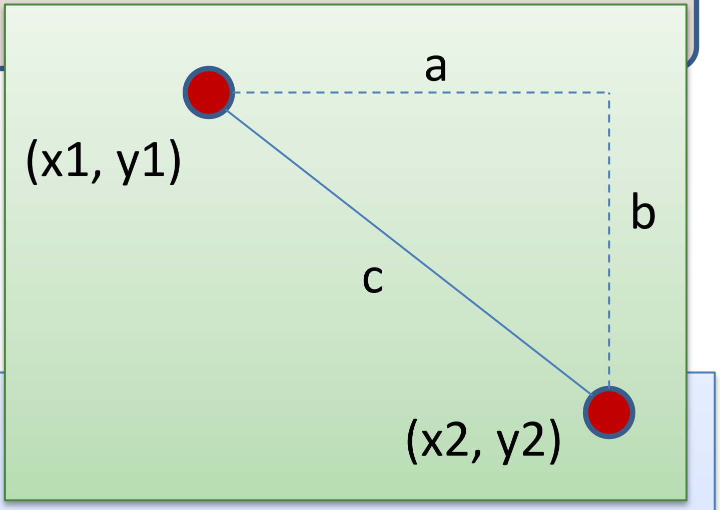
  if xd != 0.0 then
    ???
  else
    ???
```

we need an option type as the result type

Slope between two points



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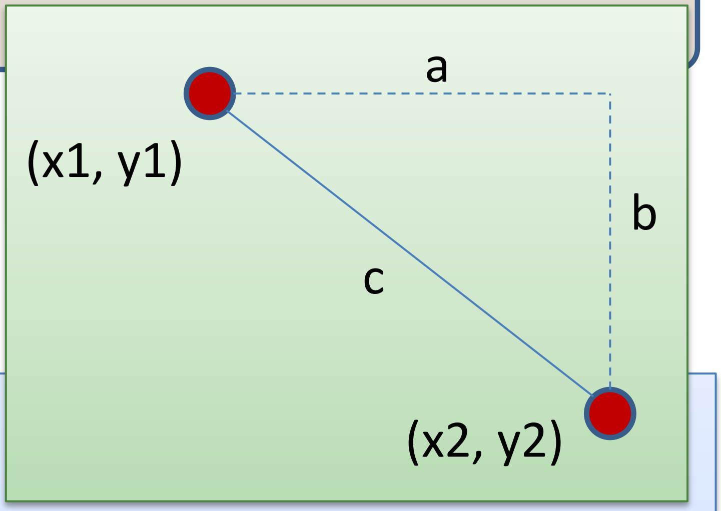
let slope (p1:point) (p2:point) : float option =
  let (x1,y1) = p1 in
  let (x2,y2) = p2 in
  let xd = x2 -. x1 in
  if xd != 0.0 then
    Some ((y2 -. y1) /. xd)
  else
    None
```

Slope between two points



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    (y2 -. y1) /. xd
  else
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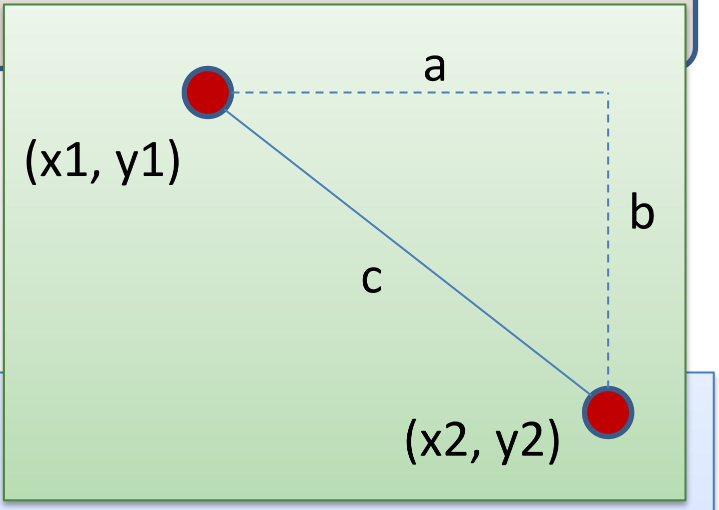
```

Has type float

Can have type float option

Slope between two points



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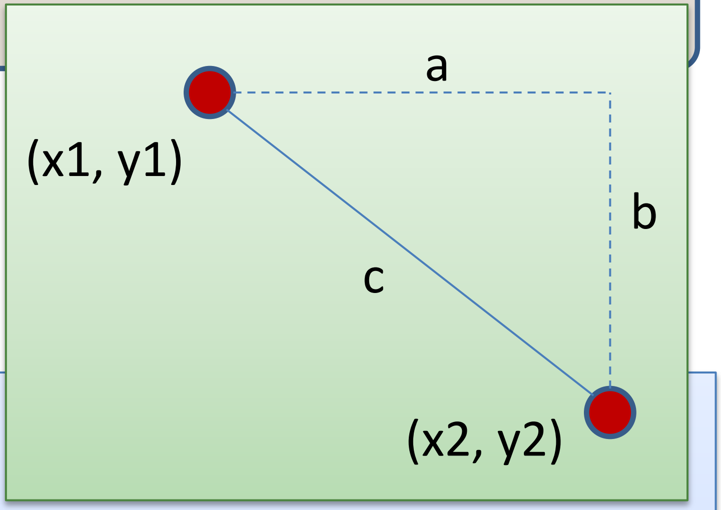
  if xd != 0.0 then
    (y2 -. y1) /. xd
  else
   None
```

Has type float

Can have type float option

WRONG: Type mismatch

Slope between two points



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let slope (p1:point) (p2:point) : float option =
  let (x1,y1) = p1 in
  let (x2,y2) = p2 in
  let xd = x2 -. x1 in
  if xd != 0.0 then
    (y2 -. y1) /. xd
  else
    None
```

Has type float

doubly WRONG:
result does not
match declared result

Remember the typing rule for if

if e1 : bool
and e2 : t and e3 : t (for some type t)
then if e1 then e2 else e3 : t

Returning an optional value from an if statement:

```
if … then

   None              : t option

else

   Some ( … )        : t option
```

How do we use an option?

```
slope : point -> point -> float option
```

returns a float option

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let print_slope (p1:point) (p2:point) : unit =
```

How do we use an option?

```
slope : point -> point -> float option


let print_slope (p1:point) (p2:point) : unit =
        slope p1 p2
```

returns a float option;
to print we must discover if it is
None or Some

How do we use an option?

```
slope : point -> point -> float option


let print_slope (p1:point) (p2:point) : unit =
  match slope p1 p2 with
```

How do we use an option?

```
slope : point -> point -> float option


let print_slope (p1:point) (p2:point) : unit =
  match slope p1 p2 with
    Some s ->
  | None ->
```

There are two possibilities

Vertical bar separates possibilities

How do we use an option?

```
slope : point -> point -> float option


let print_slope (p1:point) (p2:point) : unit =
  match slope p1 p2 with
    Some s ->
  | None ->
```

The "Some s" pattern includes the variable s

The object between | and -> is called a pattern

How do we use an option?

```
slope : point -> point -> float option


let print_slope (p1:point) (p2:point) : unit =
  match slope p1 p2 with
  | Some s ->
  | None ->
```

You can put a “|” on the first line if you want.
It is generally considered better style to do so.

How do we use an option?

```
slope : point -> point -> float option


let print_slope (p1:point) (p2:point) : unit =
  match slope p1 p2 with
  | Some s ->
      print_string ("Slope: " ^ string_of_float s)
  | None ->
      print_string "Vertical line.\n"
```

Writing Functions Over Typed Data

- Steps to writing functions over typed data:
  1. Write down the function and argument names
  2. Write down argument and result types
  3. Write down some examples (in a comment)
  4. Deconstruct input data structures
  5. Build new output values
  6. Clean up by identifying repeated patterns
- For option types:

when the input has type t option, deconstruct with:

```
match … with
   | None -> …
   | Some s -> …
```

when the output has type t option, construct with:

```
Some (…)
```

```
None
```

MORE PATTERN MATCHING

Recall the Distance Function

```
type point = float * float

let distance (p1:point) (p2:point) : float =
  let square x = x *. x in
  let (x1,y1) = p1 in
  let (x2,y2) = p2 in
  sqrt (square (x2 -. x1) +. square (y2 -. y1))
```

Recall the Distance Function

```
type point = float * float

let distance (p1:point) (p2:point) : float =
  let square x = x *. x in
  let (x1,y1) = p1 in
  let (x2,y2) = p2 in
  sqrt (square (x2 -. x1) +. square (y2 -. y1))
```

(x2, y2) is an example of a pattern – a pattern for tuples.

So let declarations can contain patterns just like match statements

The difference is that a match allows you to consider multiple different data shapes

Recall the Distance Function

```
type point = float * float

let distance (p1:point) (p2:point) : float =
  let square x = x *. x in
  match p1 with
  | (x1,y1) ->
       let (x2,y2) = p2 in
       sqrt (square (x2 -. x1) +. square (y2 -. y1))
```

There is only 1 possibility when matching a pair

Recall the Distance Function

```
type point = float * float

let distance (p1:point) (p2:point) : float =
  let square x = x *. x in
  match p1 with
  | (x1,y1) ->
     match p2 with
     | (x2,y2) ->
        sqrt (square (x2 -. x1) +. square (y2 -. y1))
```

We can nest one match expression inside another.
(We can nest any expression inside any other, if the expressions have the right types)

Better Style: Complex Patterns

we built a pair of pairs

```
type point = float * float

let distance (p1:point) (p2:point) : float =
  let square x = x *. x in
  match (p1, p2) with
  | ((x1,y1), (x2, y2)) ->
    sqrt (square (x2 -. x1) +. square (y2 -. y1))
```

Pattern for a pair of pairs: ((variable, variable), (variable, variable))

All the variable names in the pattern must be different.

Better Style: Complex Patterns

we built a pair of pairs

```
type point = float * float

let distance (p1:point) (p2:point) : float =
  let square x = x *. x in
  match (p1, p2) with
  | (p3, p4) ->
    let (x1, y1) = p3 in
    let (x2, y2) = p4 in
    sqrt (square (x2 -. x1) +. square (y2 -. y1))
```

A pattern must be consistent with the type of the expression between match … with

We use (p3, p4) here instead of ((x1, y1), (x2, y2))

Pattern-matching in function parameters

```
type point = float * float

let distance ((x1,y1):point) ((x2,y2):point) : float =
  let square x = x *. x in
  sqrt (square (x2 -. x1) +. square (y2 -. y1))
```

Function parameters are patterns too!

What’s the best style?

```
let distance (p1:point) (p2:point) : float =
  let square x = x *. x in
  let (x1,y1) = p1 in
  let (x2,y2) = p2 in
  sqrt (square (x2 -. x1) +. square (y2 -. y1))
```

```
let distance ((x1,y1):point) ((x2,y2):point) : float =
  let square x = x *. x in
  sqrt (square (x2 -. x1) +. square (y2 -. y1))
```

Either of these is reasonably clear and compact.
Code with unnecessary nested matches/lets is particularly ugly to read.
You'll be judged on code style in this class.

What’s the best style?

```
let distance (x1,y1) (x2,y2) =
  let square x = x *. x in
  sqrt (square (x2 -. x1) +. square (y2 -. y1))
```

This is how I'd do it ... the types for tuples + the tuple patterns are a little ugly/verbose ... but for now in class, use the explicit type annotations. We will loosen things up later in the semester.

Combining patterns

```
type point = float * float

(* returns a nearby point in the graph if one exists *)
nearby : graph -> point -> point option

let printer (g:graph) (p:point) : unit =
  match nearby g p with
   | None -> print_string "could not find one\n"
   | Some (x,y) ->
       print_float x;
       print_string ", ";
       print_float y;
       print_newline();
```

Other Patterns

Constant values can be used as patterns

```
let small_prime (n:int) : bool =
  match n with
  | 2 -> true
  | 3 -> true
  | 5 -> true
  | _ -> false
```

```
let iffy (b:bool) : int =
  match b with
  | true -> 0
  | false -> 1
```

the underscore pattern
matches anything
it is the "don't care" pattern

Exercises

Exercise 1: What is the type of foo below? Of bar? (bar is used but isn’t shown)

```
let foo (a,b,c) d =
  match bar a with
  | (_, Some x) -> if x then None else Some d
  | ((x,y), None) -> if a + b < 17 then Some (x ^ “hi”) else Some y
```

Exercise 2: Consider these two types:

```
type t = (bool * bool) option
type s = (bool option) * (bool option)
```

Do they contain the same “amount” of information?

Write a function to convert data with type t to type s.

And another function to convert data with type s back to type t.

What happens?

Explain when a program you write might use s instead of t and vice versa.