CSE216
Foundations of Computer Science

State University of New York, Korea

Some slides taken from Cornell's CS3110. Thanks!
https://www.cs.cornell.edu/courses/cs3110/2014fa/lecture_notes.php

Data types

Data type

- Sum Type
- Record type
- Tuple type

Sum type

```
type day = Mon | Tue | Wed | Thu | Fri |
Sat | Sun
```

- Superficially similar to an enum in Java or C
- Created a one-of type named day
- Created seven constructors from Mon to Sun
- That’s effectively how Booleans are defined in OCaml:

```
type bool = false | true
```

Example

```
# type suit = Heart | Diamond| Club | Spade;;
type suit = Heart | Diamond | Club | Spade

# Club ;;
- : suit = Club
```

Example: day_to_int

```
let day_to_int (d : day) =
  if d=Mon then 1
  else if d=Tue then 2
  else if d=Wed then 3
  else if d=Thu then 4
  else if d=Fri then 5
  else if d=Sat then 6
  else (* d=Sun *) 7
```

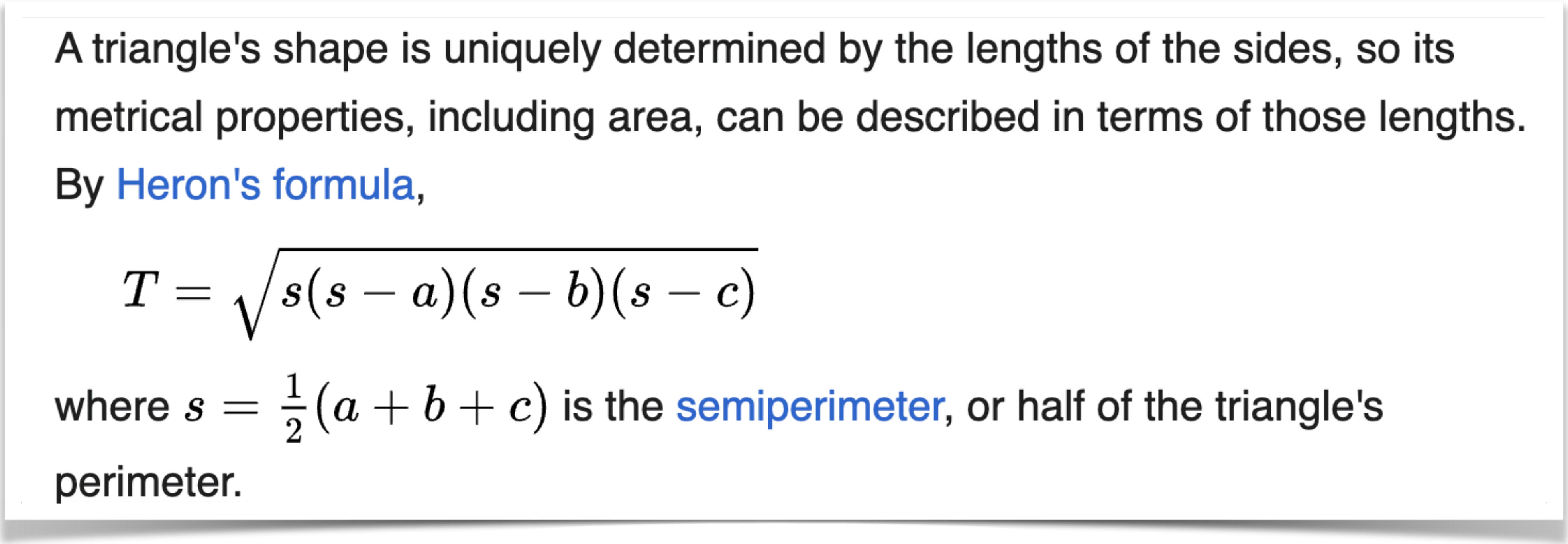
Note: Ocaml compiler/interpreter does not see new lines

An alternative (and better) way: Pattern matching

```
let day_to_int (d : day) = match d with
  Mon -> 1 (* you can put an “|” in front)
| Tue -> 2
| Wed -> 3
| Thu -> 4
| Fri -> 5
| Sat -> 6
| Sun -> 7
```

Exercise

- Define a sum type shape with constructors for Circle, Rectangle, and Triangle, each carrying appropriate dimensions. Then write a function area to compute the area of a shape



A triangle's shape is uniquely determined by the lengths of the sides, so its metrical properties, including area, can be described in terms of those lengths. By Heron's formula,

$$T = \sqrt{s(s-a)(s-b)(s-c)}$$

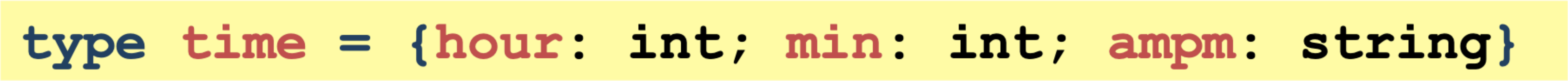
where $s = \frac{1}{2}(a+b+c)$ is the semiperimeter, or half of the triangle's perimeter.

Wikipedia

Record type

```
type time = {hour: int; min: int; ampm: string}
```

Record type



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type time = {hour: int; min: int; ampm: string}
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– Creates a *each-of type* named **`time`**

Record type

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```

- Creates a *each-of type* named **`time`**

- To *build* a record:

```
{hour=10; min=10; ampm=“am”}
```

- order of *fields* doesn’t matter; could write

```
{min=10; ampm=“am”; hour=10}
```

Record type

```
type time = {hour: int; min: int; ampm: string}
```

  - Creates a *each-of type* named `time`

- To *build* a record:

```
{hour=10; min=10; ampm=“am”}
```

  - order of *fields* doesn’t matter; could write

```
{min=10; ampm=“am”; hour=10}
```

- To *access* fields of record variable `t`:

```
t.min
```

Exercise

- Which kind of data type, sum type or record type would be better represented with record types rather than sum types?
    - Coins, which can be pennies, nickels, dimes, or quarters
    - Students, who have names and NetIDs
    - A dessert, which has a sauce, a creamy component, and a crunchy component
    - MBTI types, ISTJ, ESTJ etc

Exercise

- Define a record type student with fields name (string), id (int), and grade (float). Create a function pass that checks if a student’s grade is at least 60.0.

Pair type

- type t = int * string
- type point = float * float

Pairs

A **pair** of data: two pieces of data glued together

e.g.,

- `(1,2)`
- `(true, “Hello”)`
- `(“cs”, 3110)`

- Syntax: `(e1,e2)`

- Evaluation:
  - If `e1-->v1` and `e2--> v2`
  - Then `(e1,e2)-->  (v1,v2)`
  - A pair of values is itself a value

- Type-checking:
  - If `e1:t1` and `e2:t2`,
  - then `(e1,e2):t1*t2`

Accessing Pairs

- **Syntax:** `fst e` and `snd e`
  - *Projection functions*

- **Evaluation:**
  - If `e-->(v1,v2)`
  - then `fst e --> v1`
  - and `snd e --> v2`

- **Type-checking:**
  - If `e: ta*tb`,
  - then `fst e` has type `ta`
  - and `snd e` has type `tb`

Tuples

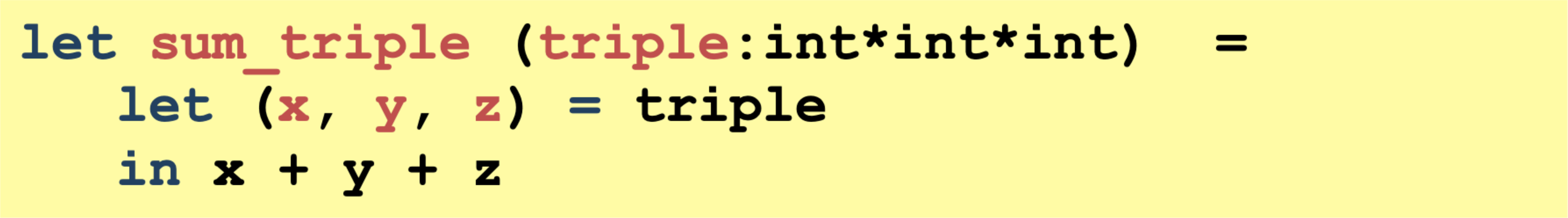
- `(e1,e2,…,en)`
- `t1 * t2 * … * tn`
- `fst e, snd e, ???`

Exercise

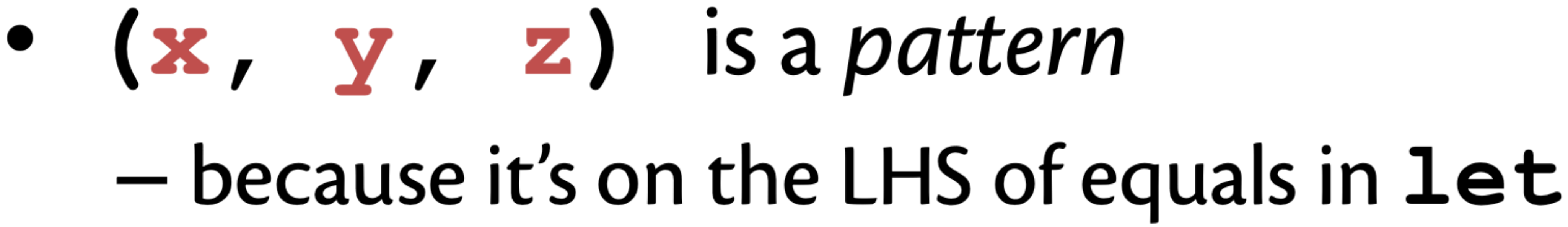
- Write a function distance that takes a tuple (x1, y1) and (x2, y2) representing two points and computes the Euclidean distance between them.

- You're given a transformation as a tuple (shift, scale) where shift is (dx, dy, dz) (floats) and scale is (sx, sy, sz) (floats), and a point (x, y, z) (floats). Write a function transform that applies the transformation: first scale the point by (sx, sy, sz), then shift by (dx, dy, dz).

Pattern matching tuples



```
let sum_triple (triple:int*int*int)  =
   let (x, y, z) = triple
   in x + y + z
```



- `(x, y, z)` is a *pattern*
  – because it's on the LHS of equals in `let`

Exercise: Rewrite sum_triple using match … with … syntax

Pattern matching records

The same syntax works for records:

```
type stooges = {larry:int; moe:int; curly:int}

let sum_stooges (s:stooges)  =
   let {larry=x; moe=y; curly=z} = s
   in x + y + z
```

More Exercises

Exercise 1

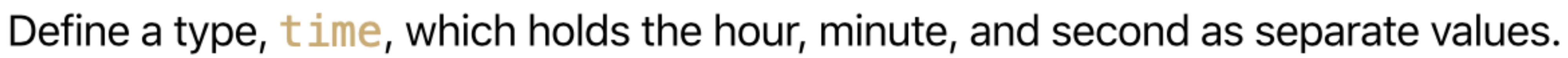
1 Define an algebraic datatype `grade` that represents a grade in a course. The datatype should include constructors for an A, B, C, D, and F.

Exercise 2

2 Then, write a function to_num that takes a grade as input and returns a numerical equivalent, where A is 4.0, B is 3.0, C is 2.0, D is 1.0, and F is 0.0. Your function should have the following type.

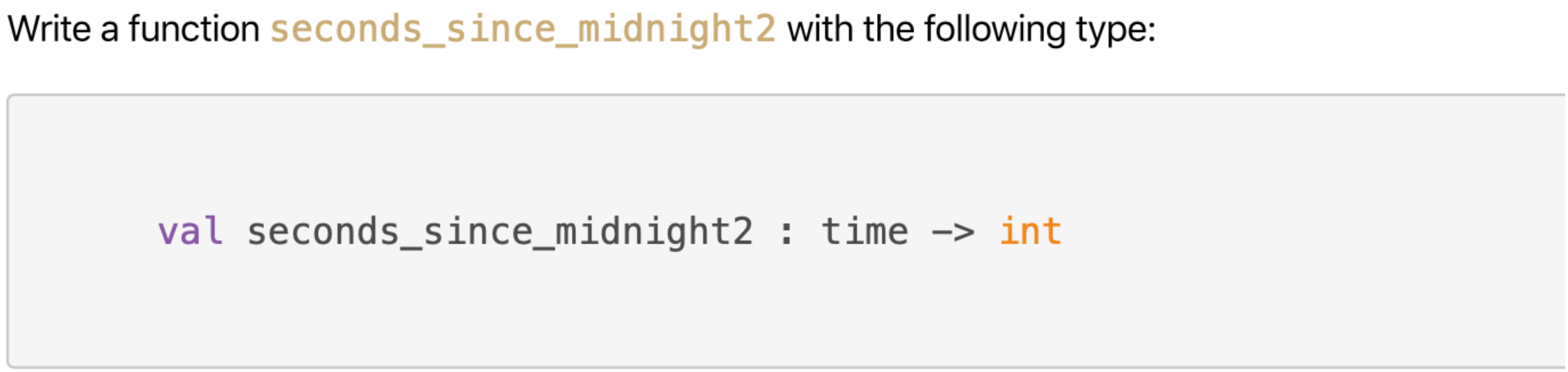
```
val to_num: grade -> float
```

Exercise 3



Define a type, `time`, which holds the hour, minute, and second as separate values.

Exercise 4



Write a function `seconds_since_midnight2` with the following type:

```
val seconds_since_midnight2 : time -> int
```