Fuzzy logic (Set & Rule):

○ **Linguistic variables:**
- Temp: {freezing, cool, warm, hot}
- Cloud Cover: {overcast, partly cloudy, sunny}
- Speed: {slow, fast}
- Taste: {sweet, too sweet, a bit sweet}

○ **Crisp variables represent precise quantities:**
- Temperature = 36 C°
- $A \in \{0,1\}$

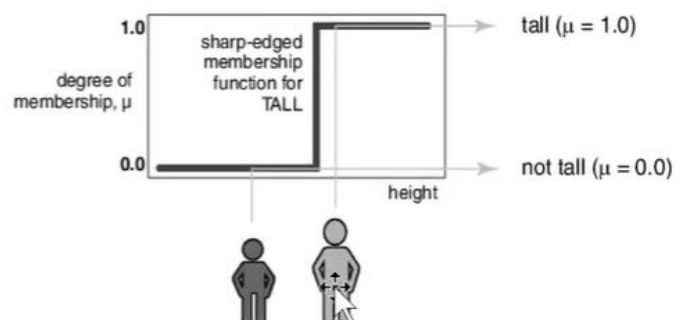### TRADITIONAL REPRESENTATION OF LOGIC

degree of membership, μ — sharp-edged membership function for TALL — tall (μ = 1.0) — not tall (μ = 0.0) — height

Slow   Fast

Speed = 0   Speed = 1

```
bool speed;
get the speed
if ( speed == 0) {
//   speed is slow
}
else {
//   speed is fast
}
```

Name	Height, cm	Degree of Membership
		Crisp sets
Chris	208	1
John	198	1
Mark	193	0
Bob	172	0

Fuzzy Sets

o For every problem must represent in terms of fuzzy sets.

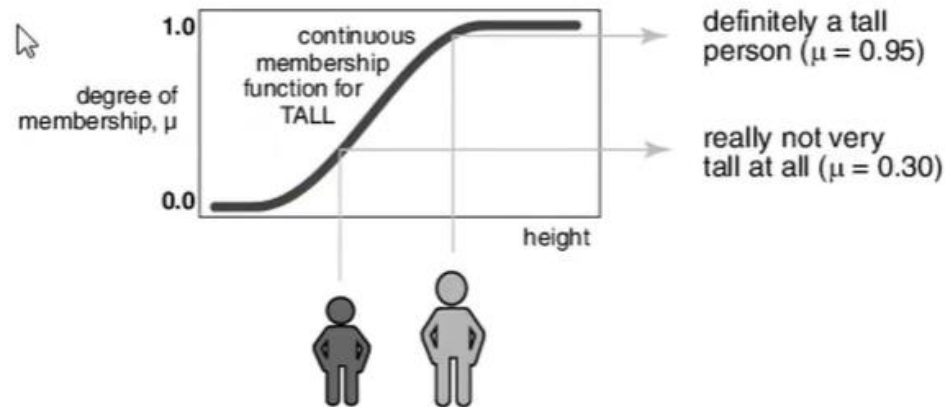| Slowest | Slow | Fast | Fastest |

```
float speed;
get the speed
if ((speed >= 0.0)&&(speed < 0.25)) {
//  speed is slowest
}
else if ((speed >= 0.25)&&(speed < 0.5))
{
//  speed is slow
}
else if ((speed >= 0.5)&&(speed < 0.75))
{
//  speed is fast
}
else // speed >= 0.75 && speed < 1.0
{
//  speed is fastest
}
```

FUZZY SETS

definitely a tall person ($\mu = 0.95$)

really not very tall at all ($\mu = 0.30$)

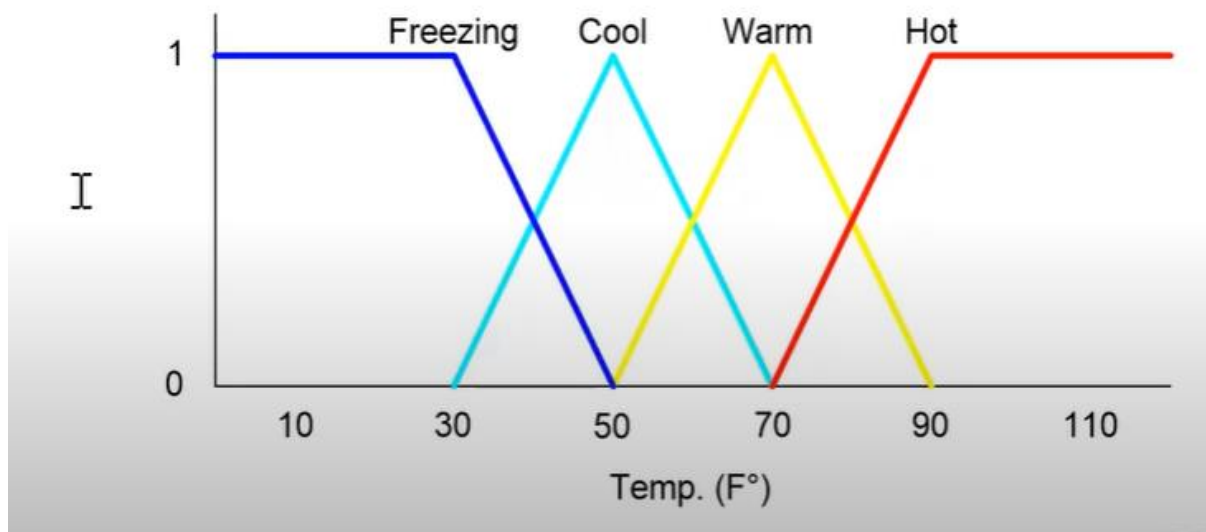| Name	Height, cm	Degree of Membership
		Fuzzy sets
Chris	208	0.95
John	198	0.82
Mark	193	0.74
Bob	172	0.30

FUZZY SETS

o *Fuzzy Linguistic Variables* are used to represent qualities spanning a particular spectrum
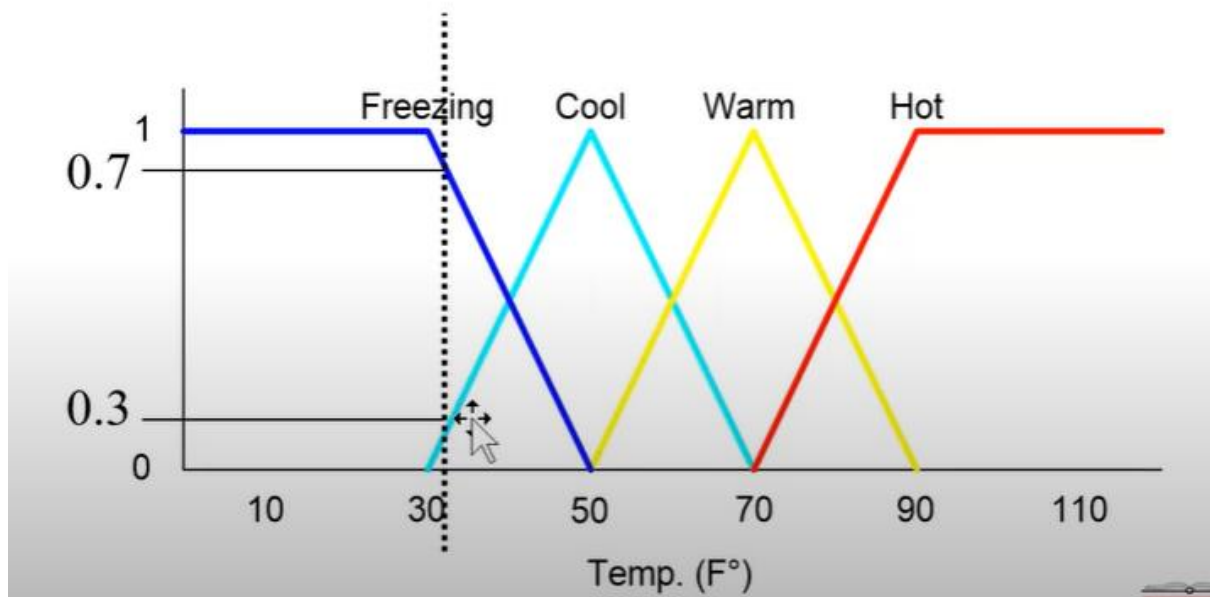Temp: {**Freezing**, **Cool**, **Warm**, **Hot**}

MEMBERSHIP FUNCTIONS

- Temp: {Freezing, Cool, Warm, Hot}
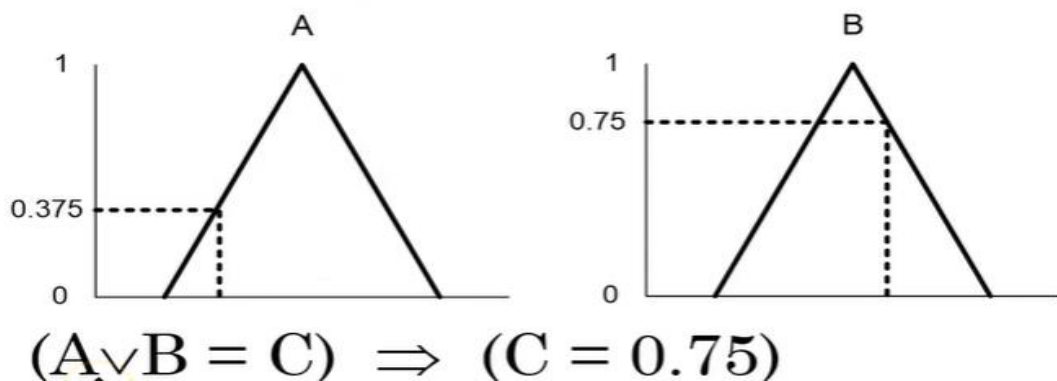- Degree of Truth or "Membership"

MEMBERSHIP FUNCTIONS

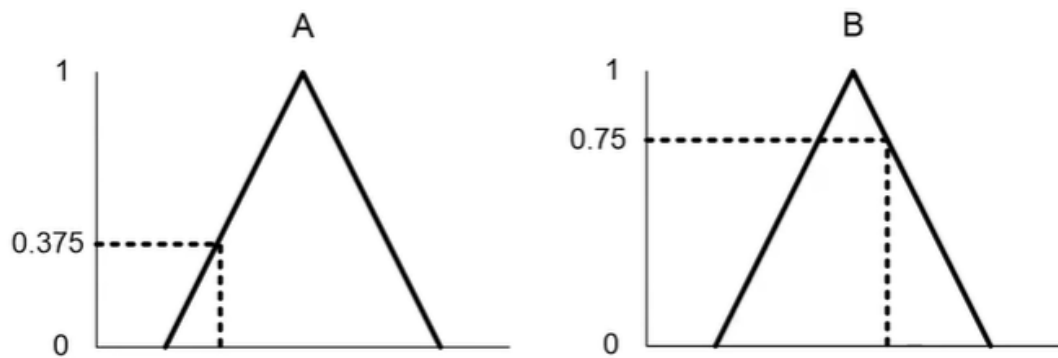- How cool is 36 F° ?
- It is 30% Cool and 70% Freezing

FUZZY DISJUNCTION

- $A \vee B = \max(A, B)$
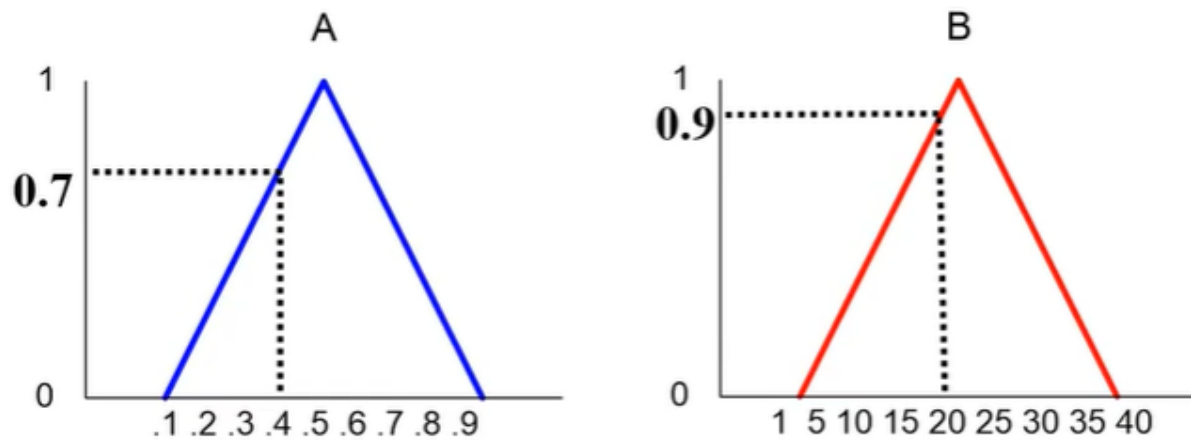- $A \vee B = C$ "Quality C is the disjunction of Quality A and B"

$$(A \vee B = C) \implies (C = 0.75)$$

Fuzzy Conjunction

- $A \wedge B = \min(A, B)$
- $A \wedge B = C$ "Quality C is the conjunction of Quality A and B"

$$(A \wedge B = C) \implies (C = 0.375)$$

Calculate A∧B given that A is 0.4 and B is 20

A

B

Determine degrees of membership:
A=0.7
B=0.9

Apply Fuzzy AND
A∧B = min(A, B) = 0.7

RULES

o If it's Sunny and Warm, drive Fast
   Sunny(Cover)∧Warm(Temp)⇒ Fast(Speed)

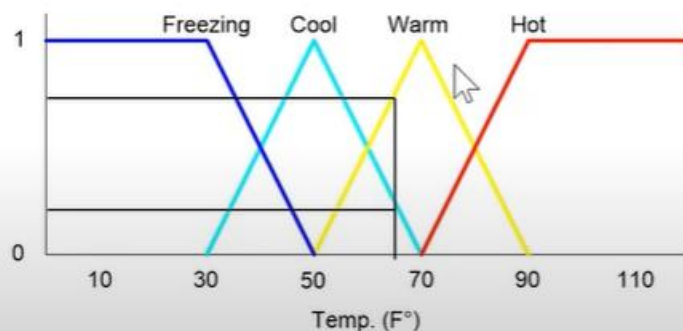o If it's Cloudy and Cool, drive Slow
   Cloudy(Cover)∧Cool(Temp)⇒ Slow(Speed)

○ How fast will I go if it is

- 65 F° (=18 °C)
- 25 % Cloud Cover ?

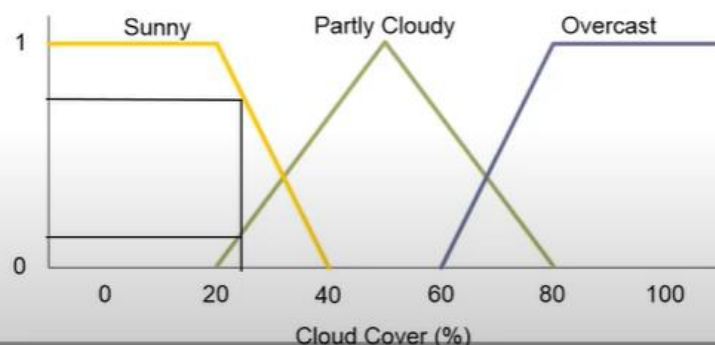## FUZZIFICATION: CALCULATE INPUT MEMBERSHIP LEVELS

○ 65 F°

$\Rightarrow$ Cool = 0.3, Warm= 0.7

FUZZIFICATION: CALCULATE INPUT MEMBERSHIP LEVELS

- 25% Cover ⇒
Sunny = 0.7, Cloudy = 0.1

RULES EVALUATION

- If it's Sunny and Warm, drive Fast
Sunny(Cover)∧Warm(Temp)⇒Fast(Speed)

$$0.7 \wedge 0.7 = 0.7$$

$$\Rightarrow \textbf{Fast = 0.7}$$

- If it's Cloudy and Cool, drive Slow
Cloudy(Cover)∧Cool(Temp)⇒Slow(Speed)

$$0.1 \wedge 0.3 = 0.1$$

$$\Rightarrow \textbf{Slow = 0.1}$$

Fuzzification:
Calculate Input Membership Levels

- 65 F°

$\Rightarrow$ Cool = 0.3, Warm= 0.7