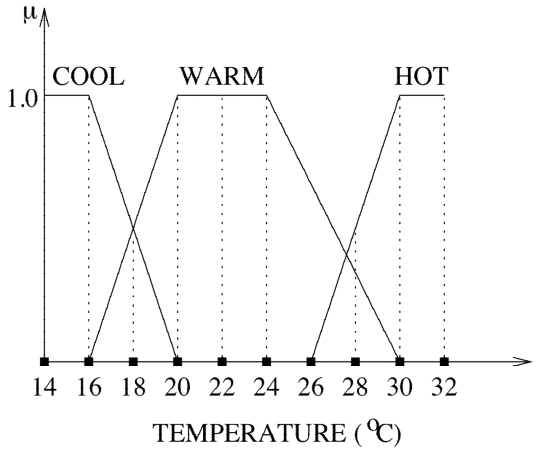
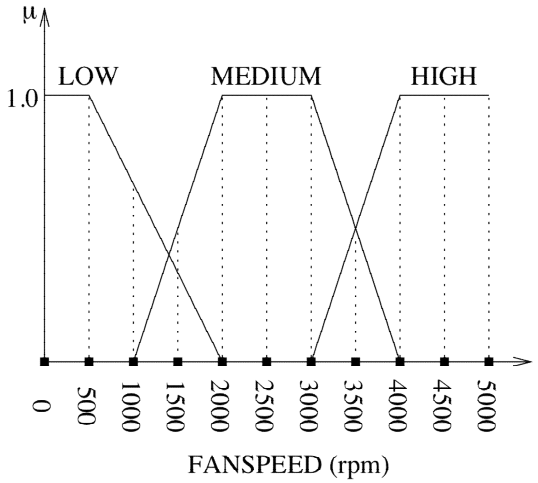
ECE 449 In-class exercise #6 **Fall 2019**

For a fuzzy controller with the algorithm

```
IF temp = hot   THEN fanspeed = high    ELSE
IF temp = warm  THEN fanspeed = medium  ELSE
IF temp = cool  THEN fanspeed = low
```

and memberships discretely defined as follows





(a) Derive the algorithm for the relation, R , using Mamdani Minimum implication. Show this relation in a matrix form.

			H								0.5	1.0	1.0	1.0
			M				0.5	1.0	1.0	1.0	0.5			
			L	1.0	1.0	0.66	0.33							
H	W	C		0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000
		1.0	14	1.0	1.0	0.66	0.33	0	0	0	0	0	0	0
		1.0	16	1.0	1.0	0.66	0.33	0	0	0	0	0	0	0
	0.5	0.5	18	0.5	0.5	0.5	~~0.33~~,~~0.5~~ 0.5	0.5	0.5	0.5	0.5	0	0	0
	1.0		20	0	0	0	0.5	1.0	1.0	1.0	0.5	0	0	0
	1.0		22	0	0	0	0.5	1.0	1.0	1.0	0.5	0	0	0
	1.0		24	0	0	0	0.5	1.0	1.0	1.0	0.5	0	0	0
	0.66		26	0	0	0	0.5	0.66	0.66	0.66	0.5	0	0	0
0.5	0.33		28	0	0	0	0.33	0.33	0.33	0.33	~~0.33~~,~~0.5~~ 0.5	0.5	0.5	0.5
1.0			30	0	0	0	0	0	0	0	0.5	1.0	1.0	1.0
1.0			32	0	0	0	0	0	0	0	0.5	1.0	1.0	1.0

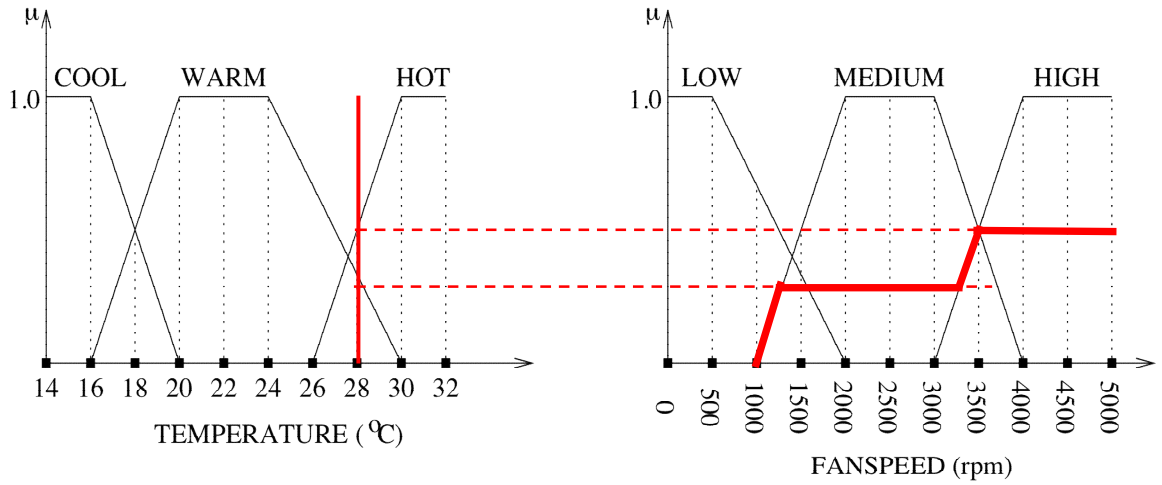
(b) For a temperature of 28°C, derive the corresponding fuzzy fan speed and sketch its m.f.

$\{28\circ C\} \circ R = [0\ 0\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 0] \circ$

	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
14	1.0	1.0	0.66	0.33	0	0	0	0	0	0	0
16	1.0	1.0	0.66	0.33	0	0	0	0	0	0	0
18	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0	0
20	0	0	0	0.5	1.0	1.0	1.0	0.5	0	0	0
22	0	0	0	0.5	1.0	1.0	1.0	0.5	0	0	0
24	0	0	0	0.5	1.0	1.0	1.0	0.5	0	0	0
26	0	0	0	0.5	0.66	0.66	0.66	0.5	0	0	0
28	0	0	0	0.33	0.33	0.33	0.33	0.5	0.5	0.5	0.5
30	0	0	0	0	0	0	0	0.5	1.0	1.0	1.0
32	0	0	0	0	0	0	0	0.5	1.0	1.0	1.0

$$= [0\ 0\ 0\ 0.33\ 0.33\ 0.33\ 0.33\ 0.5\ 0.5\ 0.5\ 0.5]$$

This results can be represented graphically as follows:



(c) Derive the crisp controller output using the SCOG method.

$$\text{speed}^* = \frac{0.33\cdot(1500+2000+2500+3000)+0.5\cdot(3500+4000+4500+5000)}{0.33+0.33+0.33+0.33+0.5+0.5+0.5+0.5} =$$

$$= \frac{3000+8500}{3.\overline{3}\,\overline{3}} = 3{,}450 \text{ rpm}$$

Note: What if the crisp input value is not exactly from the discrete universe of *X*, e.g 29°C?

- Include 29°C in the universe of discourse of X (increase resolution); speed* = 3,915 rpm
- Represent 29°C as interval [28,30]; speed* = 3,780 rpm
- Represent 29°C as triangular m. f. {x, 28, 29, 30}; speed* = 3,455 rpm