1. Fig. 15 shows a uniform shelf AB of weight WN.
The shelf is 180 cm long and rests on supports at points C and D. Point C is 30 cm from A and point D is 60 cm from B.

side view

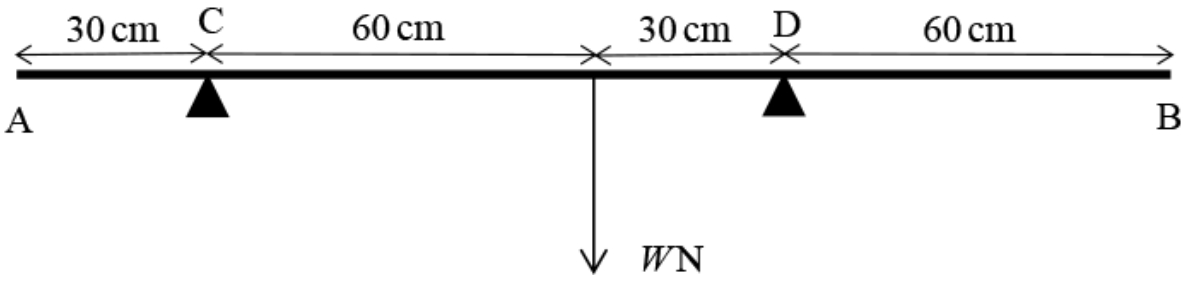

Fig. 15

Determine the range of positions a point load of 3 W could be placed on the shelf without the shelf tipping. [6]

2. A non-uniform rod 0.8 m long rests horizontally on smooth pegs A and B at each end of the rod. The contact forces at A and B are 10 N and 15 N respectively, as shown in Fig. 2.

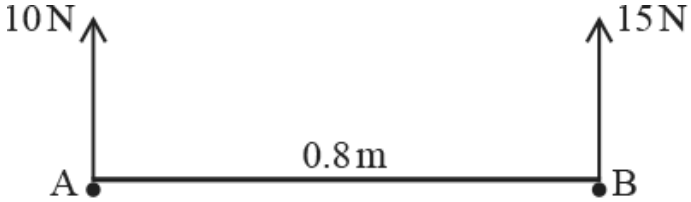

Fig. 2

Calculate the distance of the centre of mass of the rod from A. [3]

3. A rod of length 2 m hangs vertically in equilibrium. Parallel horizontal forces of 30 N and 50 N are applied to the top and bottom and the rod is held in place by a horizontal force FN applied xm below the top of the rod as shown in Fig. 7.

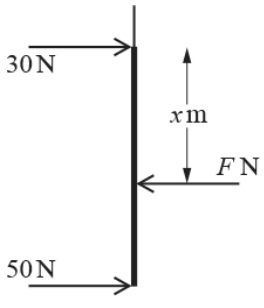

Fig. 7

(a) Find the value of F. [1]

(b) Find the value of x. [2]

4. Fig. 7 shows a rectangular lamina ABCD with sides AB of length 60 cm and AD of length 50 cm. The lamina is lying flat on a smooth horizontal surface, and is acted on by the following five horizontal forces.

- 45 N at A in the direction BA
- 40 N at D in the direction AD
- 27 N at C in the direction BC
- Y N at A in the direction DA
- X N at E in a direction perpendicular to the edge BC

The lamina is in equilibrium. The distance BE is d cm.

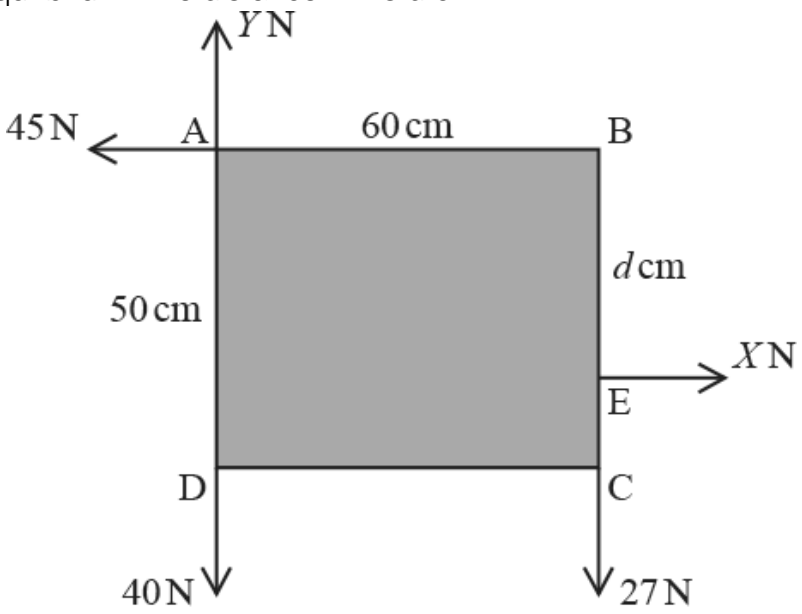

Fig. 7

Calculate the values of each of the following.

- X
- Y
- d

[4]

5. Fig. 3 shows a rod AB which is 0.9 m long and hangs vertically from a smooth hinge at A. The rod can rotate about A in a vertical plane. Forces of 100 N and 60 N act at right angles to AB in this plane. Their points of application are 0.3 m and 0.75 m respectively below A.

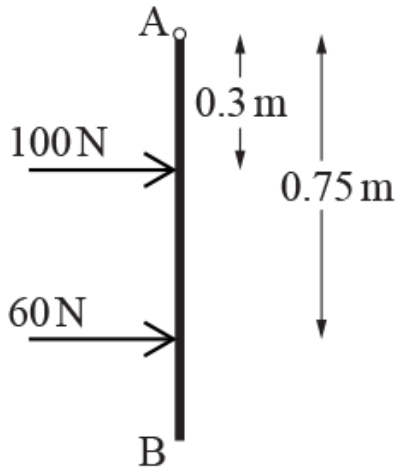

Fig. 3

(a) Find the combined moment of these forces about A. [2]

The rod is held in equilibrium by a force of F N which is also at right angles to the rod in the same vertical plane.

(b) Find the least possible value of F. [2]

(c) Explain how the rod can be in equilibrium when the resultant of these three forces is not zero. [2]

END OF QUESTION paper

Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1			Let the reactions of the supports on the shelf be U N at C and V N at D Neither U nor V can be negative if the shelf does not tip Any position between C and D must give $U > 0$ and $V > 0$ Consider putting the load between A and C, x cm from C cw moments about C If $V \geq 0$ then $W \times 60 \geq 3W \times x$ so $x \leq 20$ Consider putting the load between D and B, y cm from D anti-cw moments about D If $U \geq 0$ then $W \times 30 \geq 3W \times y$ so $y \leq 10$ The load must be placed not closer than 10 cm to A and 50 cm to B oe	M1(AO2.2a) B1(AO2.2a) M1(AO3.1b) A1(AO1.1) B1(AO3.1b) A1(AO3.2a) [6]	May be implied Need not show but must be stated moments about C allow < allow < Must be clear statement and include CD
			Total	6	
2			Vertical equilibrium: weight = 10 + 15 = 25 N Moments about A: $25x = 15 \times 0.8$ $x = 0.48$ m	B1(AO1.1a) M1(AO3.1b) A1(AO1.1b) [3]	soi or take moments about other points
			Total	3	
3		a	$F = 30 + 50 = 80$ N	B1 (AO 1.1a) [1]	Cao Examiner's Comments This was a routine mark for which almost all candidates

					were credited, the only mistake seen was to find the difference between 50 N and 30 N,
		b	Taking moments about the top of the rod $Fx = 50 \times 2$ $x = 1.25$ m	M1 (AO 3.3) A1 (AO 1.1b) [2]	Or any other suitable point Cao All necessary terms must be present. Each term must be a product of a force and a length. Examiner's Comments Most candidates successfully took moments about the top of the rod to easily obtain the correct answer. Candidates that attempted to take moments about the centre of the rod often encountered problems with their positioning of *F* with respect to the centre.
			Total	**3**	
4			Resolve →: $X - 45 = 0 \Rightarrow X = 45$ Resolve ↑: $Y - 27 - 40 = 0 \Rightarrow Y = 67$ Moments about A: $Xd - 27 \times 60 = 0$ $d = \frac{27 \times 60}{45} = 36$	B1 (AO 1.1a) B1 (AO 1.1a) M1 (AO 3.4) A1 (AO 1.1) [4]	oe; any moments equation must be correct, apart from sign errors FT their value for *X* Answer for *d* must correspond to cm units; do not accept 0.36 or 0.36m.
			Total	**4**	
5		a	Taking moments about A: $0.3 \times 100 + 0.75 \times 60$ = 75 Nm anticlockwise	M1 (AO 1.1b)	Allow for one moment only, but if two terms present, both Do not allow for the total of a force and a moment

				A1 (AO 1.1b) [2]	must be moments cao; direction needed	
		b	Minimum force when applied at B: 0.9 $F = 75$ $F = 83.3$	M1 (AO 3.1b) A1 (AO 1.1b) [2]	Forming equilibrium equation with distance 0.9 FT their moment in (a)	
		c	The hinge provides an additional [horizontal] force at A But this will not have a moment about A	B1 (AO 3.2a) B1 (AO 3.2a) [2]	Must mention either A or the hinge Must mention moment about A	Do not allow either mark for an argument based on the weight
			Total	**6**		