

# Motion and Force in a Gravitational Field

## Revision Problems 5: Torque and Equilibrium

Due: \_\_\_\_\_

Name: \_\_\_\_\_ **ANSWERS** \_\_\_\_\_

(20 marks total)

1. We say that objects are more stable if they have a wide base and a low centre of gravity. Explain this using the concept of torque. (3 marks)

Objects with a low centre of mass and wide base have a large restoring torque when tilted. [1 mark]

Due to wide base, centre of mass is some distance from the edge of the base so torque tends to rotate object back to centre. [1 mark]

Object has to rotate through a large angle before centre of mass is beyond base which would then provide a torque to tip object over. [1 mark]

2. Label the following diagrams as stable, unstable or neutral. (3 marks)



unstable



neutral



stable [3 marks]

3. A claw hammer is be used to remove a nail from a piece of wood as shown. Calculate the pulling force,  $F$ , in the situation shown? (2 marks)

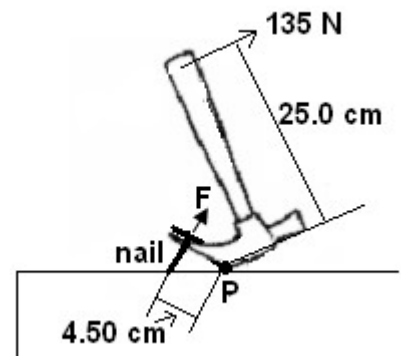
$$\Sigma CM = \Sigma ACM$$

$$135 \times 0.25 = F \times 0.045 \quad [1 \text{ mark}]$$

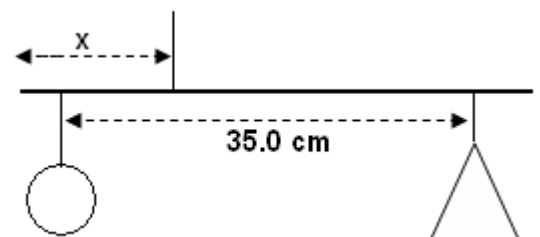
$$33.75 = 0.045F$$

$$F = 750 \text{ N}$$

$$F = 7.50 \times 10^2 \text{ N} \quad [1 \text{ mark}]$$



4. A child's mobile has different shapes at each end of a 35.0 cm rod (assume mass of rod is insignificant). The mass of the ball is 60.0 g and the mass of the triangle is 48.0 g. How far from the triangle should the rod be suspended to hang horizontal? (4 marks)



$$\Sigma CM = \Sigma ACM$$

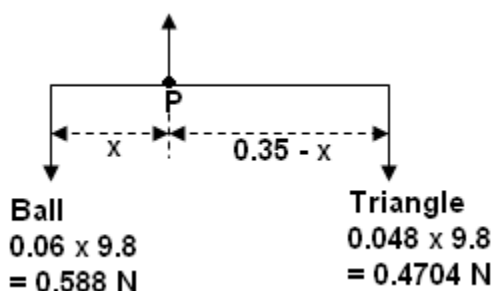
$$0.470 \times [0.35 - X] = 0.588 \times X \quad [2 \text{ marks}]$$

$$0.1645 - 0.47X = 0.588X$$

$$0.1645 = 1.058X$$

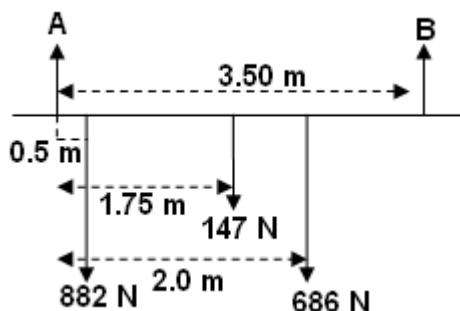
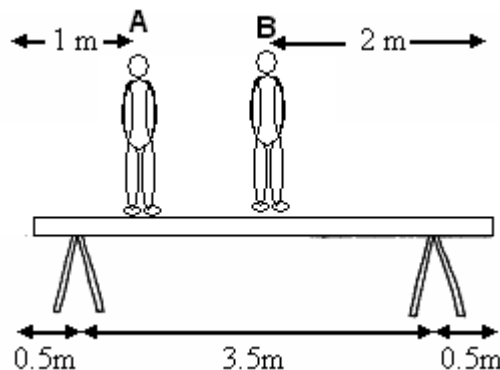
$$X = 0.1554 \quad [1 \text{ mark}]$$

attach string to rod 0.155 m from ball [1 mark]



5. In order to paint a wall, two men are standing on a supported uniform plank of mass 15.0 kg as shown. (diagram not to scale). Man A, who has a mass of 90.0 kg is 1.00 m from one end while man B, who has a mass of 70.0 kg is 2.00 m from the other end. The supports are 0.500 m from each end of the plank. Calculate how much of the total weight each of the trestle stands supports.

(4 marks)



Take moments about A

$$\Sigma CM = \Sigma ACM$$

$$(882 \times 0.5) + (147 \times 1.75) + (686 \times 2.0) = B \times 3.5$$

$$441 + 257.25 + 1372 = 3.5 B$$

$$2070.25 = 3.5 B$$

$$B = 592 \text{ N up}$$

[2 marks]

F up = F down

$$591.5 + A = 882 + 147 + 686$$

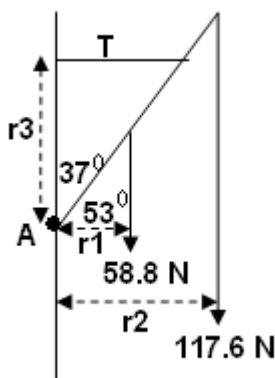
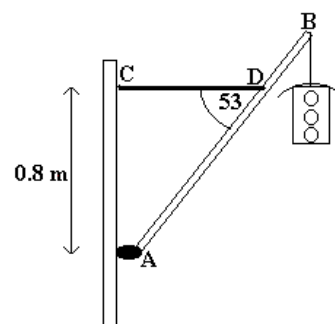
$$A = 1715 - 591.5$$

$$= 1123.5$$

$$A = 1.12 \times 10^3 \text{ N}$$

[2 marks]

6. A traffic light hangs from a structure as shown. The uniform metal pole AB is 5.50 m long and has a mass of 6.00 kg. The mass of the traffic light is 12.0 kg. The cable CD is attached 0.800 m from point A. Determine the tension in the horizontal cable CD. (Assume the cable has no mass itself.) (4 marks)



Calculate perpendicular distance:

$$r_1 = 2.75 \cos 53$$

$$= 1.6550 \text{ m}$$

[1 mark]

$$r_2 = 5.5 \cos 53$$

$$= 3.3100 \text{ m}$$

[1 mark]

$$r_3 = 0.800 \text{ m}$$

Take moments about A

$$\Sigma CM = \Sigma ACM$$

$$(58.8 \times 1.655) + (117.6 \times 3.31) = T \times 0.80 \quad [1 \text{ mark}]$$

$$97.314 + 389.256 = 0.80T$$

$$486.57 = 0.8T$$

$$T = 608 \text{ N}$$

[1 mark]