1

(a) The moment of a force about a point is the product of the force and the perpendicular distance from that point to the line of action of the force.

(b) **(i)** Taking moments about point A and since the sum of the clockwise moments must equal the sum of the anticlockwise moments,

$$8.0(9.81)\left(\frac{7.5}{2}\right)\cos 37° + 12.0(9.81)(7.5\ \cos 37°) = T(3.8)$$
$$T = 2.5 \times 10^2\ N$$

(ii) Since net horizontal force must be zero,
$$F_H = 2.5 \times 10^2\ N$$

Since net vertical force must be zero,
$$F_V = 8.0(9.81) + 12.0(9.81)$$
$$= 2.0 \times 10^2\ N$$
$$F = 3.2 \times 10^2\ N$$
$$\tan\theta = \frac{F_V}{F_H}$$
$= 39°$ (anticlockwise above horizontal)

2

(a) For a system in equilibrium, sum of clockwise moments about a (or any) point equals sum of anticlockwise moments about the same point

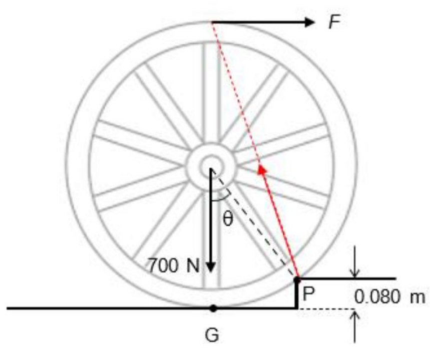
(b) Let the length of the rod be L. Take moment about the point of contact between the rod and the ground.

$$1000\left(\frac{L}{2}\right)\cos 30° = (T\sin 17°)L$$
$$T = 1480\ N$$

3

(a)
$$\cos\theta = \frac{0.60 - 0.08}{0.60}$$
$$\theta = 30°$$

(b)



(c) Using principle of moments and taking moments about P:
$$700 \times 0.60\sin 30° = F(1.20 - 0.08)$$
$$F = 187.5 \approx 190\ N$$

(d) Sum forces vertically: $R_y = 700\ N$
Sum forces horizontally: $R_x = 188\ N$
$R = \sqrt{700^2 + 190^2}$
≈ 730

4

(a) The net force is zero in any direction.
The net moment about any point is zero.

(b) **(i)** Taking moments about point C, moments due to T_1 and T_2 are zero. Since point G is the centre of gravity of the beam and worker, their combined weight must be acting at G. The line of action of their combined weight must also pass through C for the net moment to be zero about C. Therefore, the vertical line through G must pass through C.

(ii) By Principle of Moments, taking moments about C,
Let distance MG be x and distance DG be y.

$W_b x = W_w y$
$2700x = 900y$
$y = 3x$
$MD = AD - AM = 4.0 - 3.0 = 1.0$
$MD = y + x = 4x$
$x = 0.25\ m$
$MG = 0.25\ m$
$DG = 0.75\ m$

(iii) For horizontal equilibrium,
$T_1 \cos(60.0° - 2.8°) = T_2 \cos(60.0° + 2.8°)$
$T_1 = \dfrac{\cos 62.8°}{\cos 57.2°} T_2$
$T_1 = 0.8438\ T_2$
For vertical equilibrium,
$T_1 \sin 57.2° + T_2 \sin 62.8° = 2700 + 900$

$T_2 = 2250\ N$

5

(a) Let n be the number of 5.0 g masses.

By Principle of Moments, take moments about the edge of the table, sum of clockwise moments = sum of anti-clockwise moments

$(1.5)(9.81)\left(\dfrac{0.10}{2}\right) = (0.11)(9.81)(0.50 - 0.10) + n(5.0 \times 10^{-2})(9.81)(0.80)$
$n = 7.75$

Maximum number of masses is 7.

(b) Let tension in the string be T.

Consider forces acting on the rule and taking moments about the edge of the table, string holding the 1.5 kg mass will cause a reduction of anti-clockwise moments of $T\left(\frac{0.10}{2}\right) = 0.050\ T$. The string attached to the rule at midpoint will cause a reduction of clockwise moments of $T \sin 60° (0.40) = 0.346\,T$. Since there is a net anti-clockwise moment on the metre rule, more masses can be placed.

6

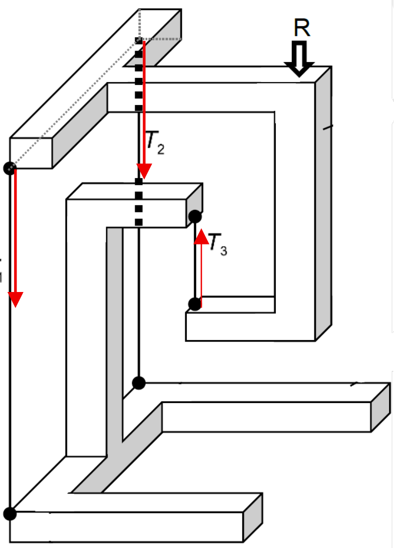
(b) Taking moments about the hinge,

$$2(47.5)\left(\frac{3}{5}\right)(0.800) = W\left(\frac{1.3}{2}\right)$$
$$W = 70.2\ N$$
$$m = \frac{70.2}{9.81} = 7.2\ kg$$

(c) The tension in the cables has a horizontal component, while the weight has only vertical component. For the canopy to be in equilibrium, there must be a horizontal component by the hinge away from the hinge. The sum of the vertical component of the tensions in both cables is less than the weight, hence the force by the hinge has a vertical upward component.

7

(a)



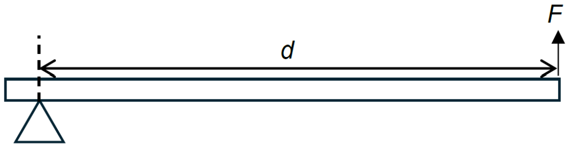
(b) By Principle of Moments, taking moments about the base of wire 1, sum of clockwise moments = sum of anti-clockwise moments

$$(14.5)(m_p g) = 10.0\,T_3$$
$$T_3 = \frac{14.5}{10.0}(m_p g)$$
$$= \frac{14.5}{10.0}(350 \times 10^{-3})(9.81)$$
$$= 4.98\ N$$

(c) P is in vertical translational equilibrium,
R adds additional downward force.
T_3 is the only upward force and so must provide additional tension, more likely to snap.

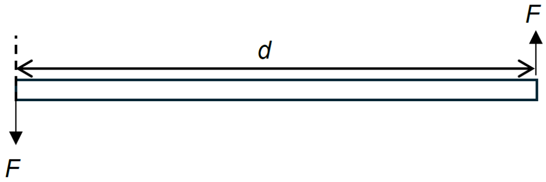
8

(a) Moment of a force:



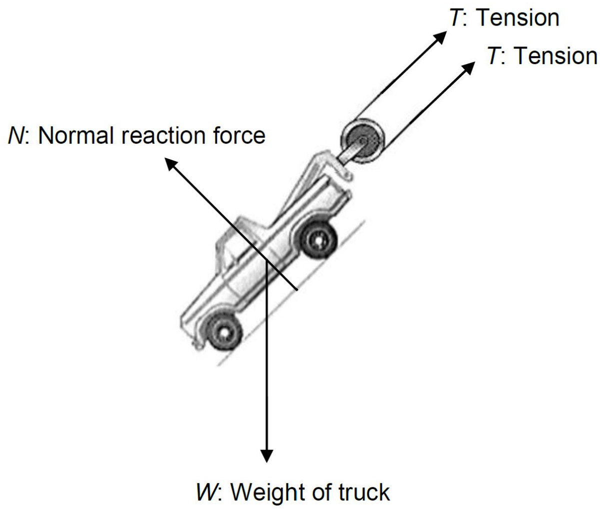
The moment of a force about an axis is the product of the force and the perpendicular distance from the line of action of the force to the axis.

Torque of a couple:



Torque of couple is defined as the product of one force F and the perpendicular distance d between the two forces.

(b) **(i)**



(ii) Since the truck is in equilibrium,
$m_T g \sin 40° = 2T$

Taking moments about the centre of the pulley, sum of clockwise moments = sum of anti-clockwise moments

$mg(3r) = Tr$

$mg(3r) = \frac{m_T g \sin 40°}{2} r$

$m = \frac{1500 \sin 40°}{3(2)}$

$m = 161\ kg$

9

(a) **(i)** Horizontal net force is zero:
$F_A \sin\theta = 20.0 \sin 35°$

Vertical net force is zero:
$F_A \cos\theta + 20.0 \cos 35° = 30.0$
$F_A \cos\theta = 13.617$

$\tan\theta = 0.84244$
$\theta = 40.1°$

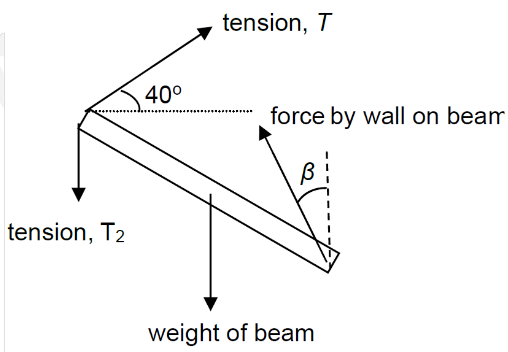
$F_A = 17.8\ N$

(ii) When both angles are 90° at the same time, both F_A and F_B are horizontal and there is no vertical component force. There must be a vertically upward force that is equal in magnitude and opposite in direction to the weight of object Q to maintain vertical equilibrium.

(b) The total clockwise moment about pivot A due to the weight of rod is unchanged. If the spring is aligned vertically along YB, the perpendicular distance of the line of action of the spring force from pivot A will decrease. Therefore, the spring force must increase to maintain the same total anticlockwise moment about the pivot.

10

(b) **(i)**



(ii) Let x be the distance of c.g of beam from the hinge.
Taking moments about hinge,
sum of clockwise moments = sum of anticlockwise moments

$120\ (5 \sin 60°) = 5g\ (5 \sin 70°) + 20g\ (x \sin 70°)$
$x = 1.57\ m$

(iii) Vertical net force is zero:
$F_Y + 120(\sin 40°) = 5g + 20g$
$F_Y = 168.1\ N$
Horizontal net force is zero:
$F_X = 120(\cos 40°)$
$F_X = 91.93\ N$
$F = \sqrt{F_X^2 + F_Y^2} = 192\ N$
$\tan\beta = \dfrac{91.93}{168.1}$
$\beta = 29°$

Force is at an angle of 41° with the beam