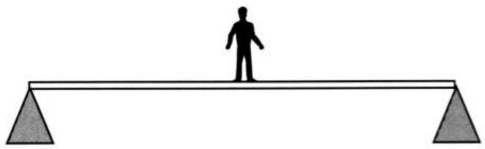
**Name:** **Index No:**

**Date:** **Class:**

## Assignment 06: Turning effect of forces

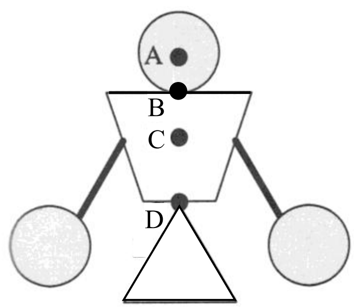
1. The diagram below shows a man of weight 800 N standing in the middle of a plank supported at the sides. The plank weighs 1000 N.



Which one of the following diagrams shows the forces acting on the plank?

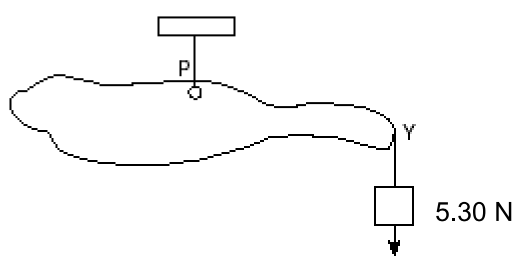

( A )

2. The diagram shows a balancing toy **pivoted on a triangular stand**. When the toy is tilted slightly, it stays at the new position.




Where is the centre of gravity of the toy? ( D )

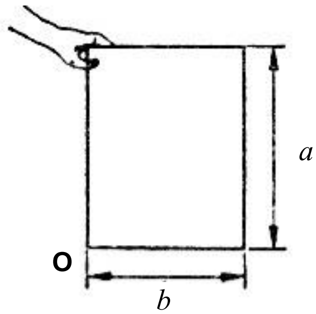
3. A thin uniform sheet of metal is cut into an irregular shape. It is 380 mm long, weighs 6.00 N and is freely suspended at point **P** which is halfway along its length. A 5.30 N weight hung at **Y** makes it balance and in equilibrium as shown in the diagram.




What is the perpendicular distance from the line of action of its weight to the point **P**?

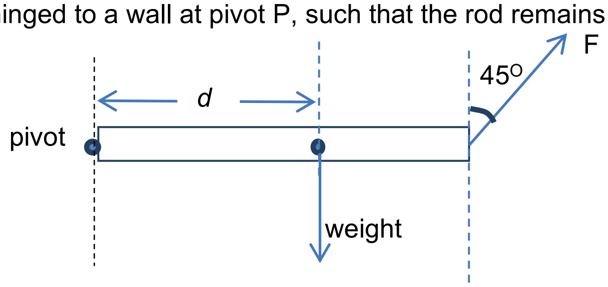
A. 3.7 mm B. 130 mm C. 170 mm D. 540 mm ( C )

4. A person exerts a horizontal force on a rectangular book such that it is just tilted about point **O** as shown in the diagram below. If the book has a weight of *W*, what is the moment of the force that is produced by the person?




A. $W\frac{a}{2}$ B. $W\frac{b}{2}$ C. $Wa$ D. $Wb$ ( **B** )

5. A force *F* of magnitude 8.20 N acts on a non-uniform rod of weight 10.0 N and length 1.00 m freely hinged to a wall at pivot P, such that the rod remains horizontal.

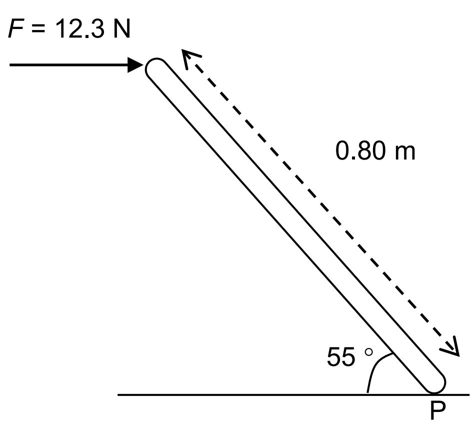



What is *d*, the distance of the centre of gravity of the rod from P?

A. 0.18 m B. 0.42 m C. 0.58 m D. 0.82 m ( **C** )

6. For each of the following cases, calculate the moment of the force, *F* about the pivot P. [4]

(a)

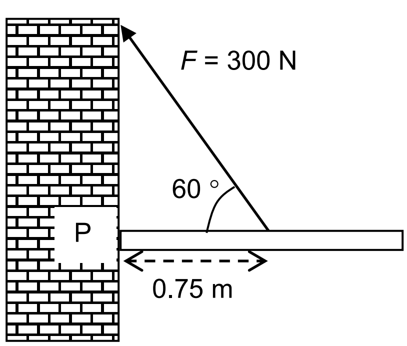



[1]: Moment of F about P = 12.3 X 0.80 sin 55°
[1]: = 8.1 N m, clockwise

Common mistake for (a) and (b):

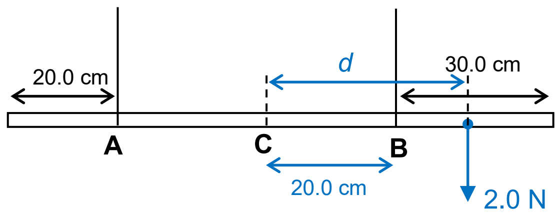
- Type of moment (i.e. clockwise or anticlockwise) is not mentioned

(b)




[1]: Moment of *F* about P = 300 sin 60° X 0.75
[1]: = 190 N m, anti-clockwise

7. A uniform metre rule of weight 0.90 N is suspended horizontally by two vertical loops of threads **A** and **B** placed at 20.0 cm and 30.0 cm from its ends respectively as shown in the diagram below.




Calculate the distance *d* from the centre of the rule, **C,** at which a 2.0 N weight should be suspended to balance the metre rule and keep it in equilibrium while

(a) making loop **A** slack, [2]

(b) making loop **B** slack. [2]

State if the distance *d* is to be on the left side or the right side of **C**.

(a) If loop A is slack, there is no tension in the loop.
Upward forces acting on rule: Tension in B
Downward forces acting on rule: Weight of metre rule; 2.0 N weight

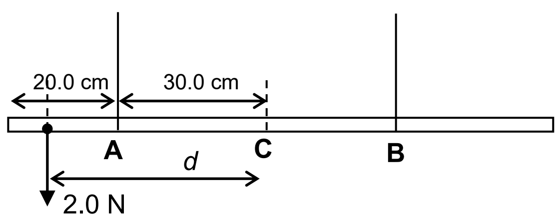
If B is pivot, 2.0 N weight must be on right side of B to balance rule.

Taking moments **about B**,
sum of clockwise moments = sum of anticlockwise moments

$2.0 \times (d - 20.0) = 0.90 \times 20.0$ [1]

$d$ = 29 cm, on the right of C [Accept: 29.0 cm] [1]

(b) If loop B is slack, there is no tension in the loop.
Upward forces acting on rule: Tension in A
Downward forces acting on rule: Weight of metre rule; 2.0 N weight




If A is pivot, 2.0 N weight must be on left side of A to balance rule.

Taking moments about A,
sum of clockwise moments = sum of anticlockwise moments

$0.90 \times 30.0 = 2.0 \times (d - 30.0)$ [1]

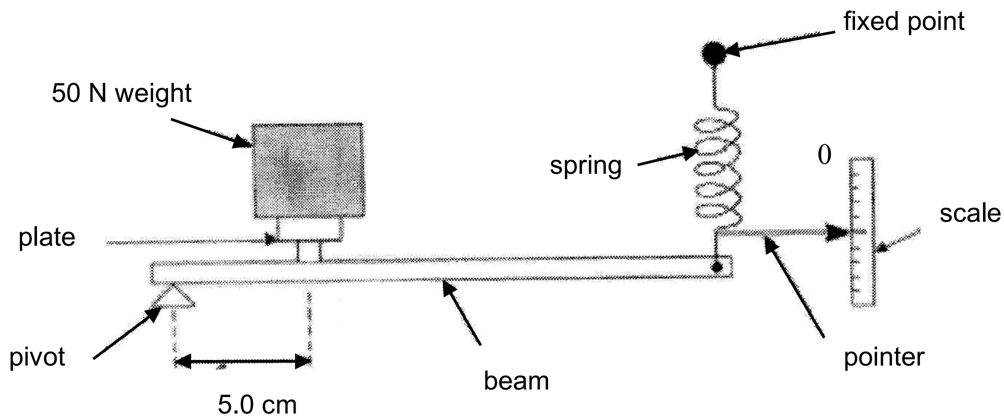
$d$ = 43.5 cm

$d$ = 44 cm, on the left of C [Accept: 43.5 cm] [1]

Common mistakes:

- *d* in (a) is not added to 20.0 cm, thus answer obtained was 9.0 cm. Likewise, *d* obtained for (b) was 13.5 cm.
- *d* in (a) and (b) were swapped as student wrongly deduced zero tension in slack loop.

8. The diagram below shows the mechanism of a weighing machine.




When the 50 N weight is placed on the plate, the spring extends until the beam is horizontal. A pointer attached to the spring moves along the scale. When the weight is removed from the plate, the **spring returns to its original length (suggesting plate's and beam's weights are negligible)**.

(a) Determine the moment of the force about the pivot due to a 50 N weight placed on the plate. [2]

Moment of force about pivot = 50 N x 5.0 cm = 250 N cm (or 2.5 N m) [1], clockwise [1]

Common mistake for (a):
- wrong unit or missing type of moment

(b) What is the direction of the force acting on the beam due to the spring? _Upwards_______ [1]

(c) What is the direction of the force acting on the spring due to the beam? _Downwards_____ [1]

Common mistake for (b) and (c):
- wrongly described force as clockwise / anticlockwise; a force is a vector which acts in one direction, thus it does not rotate CW or ACW. **Do not confuse force with torque!**

(d) Is the magnitude of the force in the spring greater than, smaller than or equal to 50 N? (Ignore the weight of the beam and the plate.) Explain your answer. [2]

For rotational equilibrium (OR for clockwise moment to be equal to anticlockwise moment about same pivot),

[1]: **spring** is **further away from pivot than 50 N weight** OR **perpendicular distance between spring force and pivot** is **greater than** that of **50 N weight and pivot**,

[1]: thus spring force is **smaller than 50 N.**

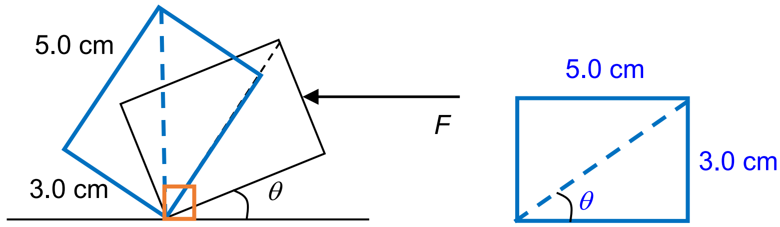
Common mistake:
- missing details in description, e.g. '50 N', 'perpendicular', 'pivot'

(e) The plate is now moved along the beam towards the spring. The rest of the weighing machine remains unchanged in design. Explain why the pointer reading obtained is higher than it should be when the 50 N weight is placed on the plate for weighing. [2]

[1]: Moving the plate results in a **larger clockwise moment of weight about pivot.**

[1]: To achieve **rotational equilibrium** (OR to **produce** a **larger anticlockwise moment about** the **same pivot** to balance this), the **spring force increased** since distance between spring and pivot is unchanged.

9. The diagram shows a uniform rectangular block maintained at an angle $\theta$ by a horizontal force $F$.




tan $\theta$ = 3.0 / 5.0

$\theta$ = 30.96°

(a) What is the maximum angle, $\theta_{max}$, the block can rotate in the direction of $F$ without toppling? Explain your answer. [2]

[1]: 90° – 30.96° = 59° (to 2 s.f.)

[1]: At this angle, the **line of action of weight passes through pivot** OR the **block's centre of gravity is directly above pivot**.

Common mistakes:
- use 'gravity' instead of 'weight'
- use 'centre of mass' instead of 'centre of gravity'
- poor description e.g. centre of gravity is perpendicular to pivot.

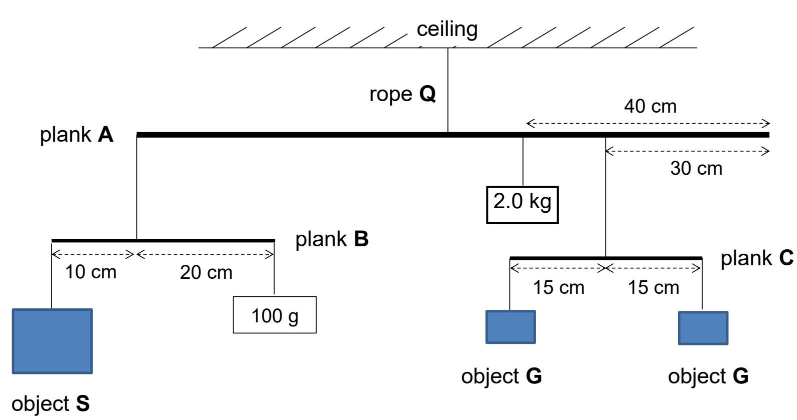
(b) From the position shown in the above diagram, describe and explain the motion of the block if $F$ were to be removed suddenly. [2]

[1]: Block **rotates clockwise about pivot** and **falls back to original position**, with its 5.0 cm side touching the table surface.

[1]: When $F$ was removed, the **block's weight**, which acts from its centre of gravity, lies within its base area and **produces** a **clockwise moment about** the **pivot**.

Common mistake:
- misinterpret 'toppling' as 'falling back to original position'; 'toppling' refers to scenario where object falls further away from original position.

10. The diagram below shows an experimental set-up to determine the mass of object **G**.




Given that the mass of planks (of **uniform** cross-sectional area) **A**, **B** and **C** are 1.2 kg, 0.90 kg and 0.85 kg respectively, and that the length of plank **A** is 1.0 m, with rope **Q** being hung at the centre of plank **A**. The entire setup is in equilibrium. Take gravitational acceleration, $g$ = 10 m s$^{-2}$.

(a) Determine the mass of object **S**. [2]

Let $M_S$ be mass of S.

Taking moments about pivot **at plank B**,

[1]: $M_s$ (10 m s$^{-2}$)(0.10 m) = (0.90 kg)(10 m s$^{-2}$)(0.050 m) + (0.10 kg)(10 m s$^{-2}$)(0.20 m)

[1]: $M_S$ = 0.65 kg

Common mistake:

- missed out clockwise moment due to weight of plank B and got 200 g instead for (a)
- likewise, weight of plank C was missing in (b)

(b) Determine the mass of object **G**. [2]

Let $M_G$ be mass of G.

Taking moments about pivot **at plank A**,

[1]: (0.65 + 0.90 + 0.10) kg (10 m s$^{-2}$)(0.50 m) = (2.0 kg)(10 m s$^{-2}$)(0.10 m)
+ [(2$M_G$ + 0.85) kg (10 m s$^{-2}$)(0.20 m)]

$M_G$ = 1.138 kg

[1]: = 1.1 kg (correct to 2 s.f.)

(c) For the calculation in (b), explain why it is not necessary to consider the weight of plank A. [1]

Plank A's **weight acts (or passes) through** the **pivot**.

Common mistake:

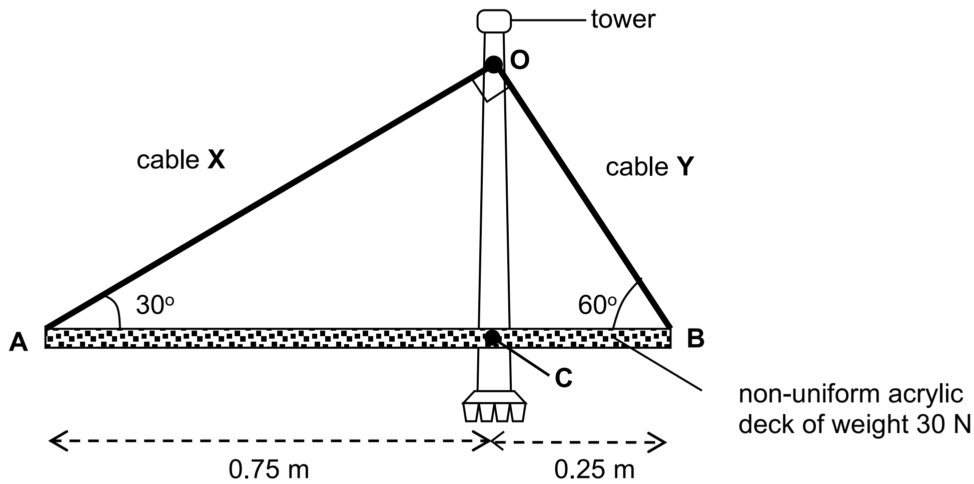
- poor description e.g. centre of gravity is at pivot => have to mention 'weight'
- rejected 'zero moment of weight of plank A about pivot' as further explanation is required to show understanding

(d) Determine the magnitude of tension in rope **Q**. [2]

[1]: Tension = (1.2 + 0.90 + 0.85 + 2.0 + 0.10 + 0.65 + 1.1 + 1.1) x 10

[1]: = 79.8 N [accept 80 N (to 2 s.f.)]

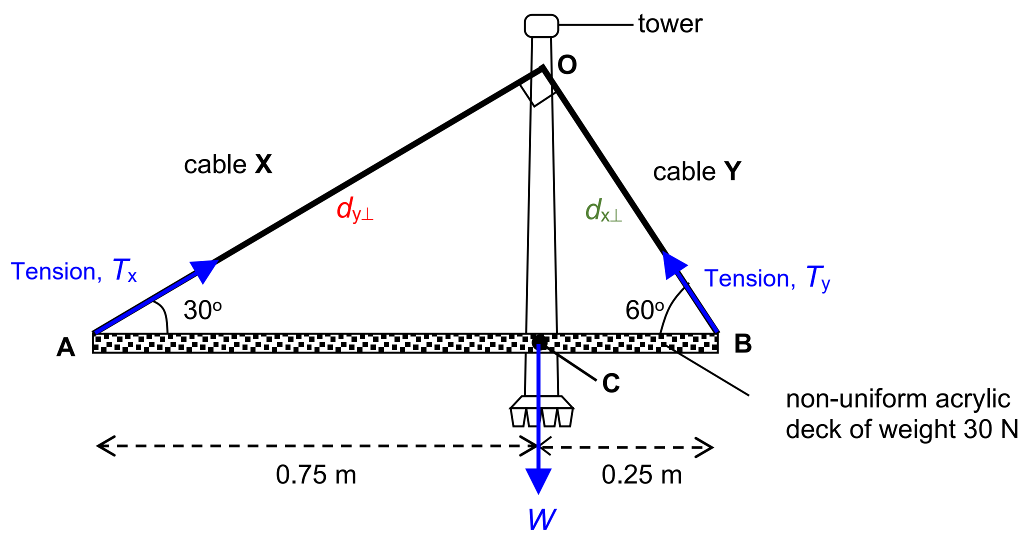
11. The diagram (not to scale) shows a model of a cabled bridge built by a student for a school project.




(a) A non-uniform, rectangular, acrylic deck, **AB**, of weight 30 N, is held at rest by the cables **X** and **Y** which are fixed to the tower at point **O**. The tower is upright and perpendicular to the deck. When in equilibrium, the deck rests on the tower at the point **C**, which is also the centre of gravity of the deck. **AOB** is a right-angle triangle.

Ignore the forces exerted by the tower on the deck.

On the above diagram, draw and label, the weight $W$ acting on the acrylic deck. [1]




(b) Determine the magnitude of the tension in the cable **X,** $T_x$. [2]

Taking moments **about B**,

sum of clockwise moments = sum of anticlockwise moments

$T_x\,(d_{x\perp}) = W\,(0.25)$

[1]: $T_x\,(1.00 \sin 30^\circ) = (30)(0.25)$

[1]: $T_x$ = <u>15 N</u> (to 2 s.f.)

(c) Determine the magnitude of the tension in the cable **Y,** $T_y$. [2]

Taking moments **about A**,

sum of clockwise moments = sum of anticlockwise moments

$$T_y\,(d_{y\perp}) = W\,(0.75)$$

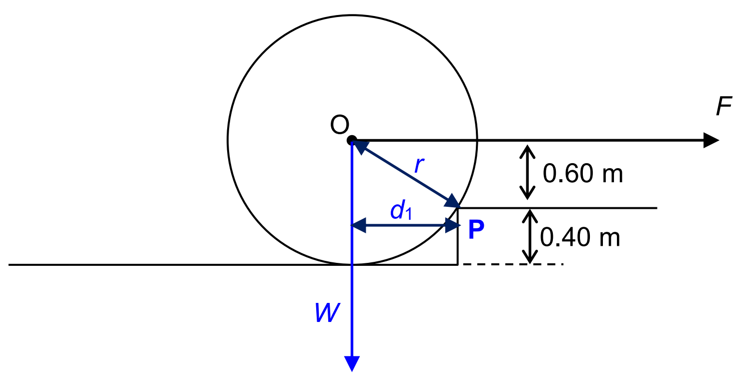
[1]: $T_y\,(1.00 \sin 60^o) = (30)(0.75)$

[1]: $T_y$ = 26 N (to 2 s.f.)

Common mistake:

- For (a): missing label of '*W*'; assumed CG is at mid-point of AB
- For (b) and (c): unable to identify correct perpendicular distance

12. The diagram below shows a wheel of mass 15.0 kg and radius 1.00 m. The point O is the centre of the wheel. It is being pulled by a horizontal force, *F*, against a step of 0.40 m high. **Take gravitational acceleration, $g = 10$ m s$^{-2}$.**




(a) Indicate the weight *W* of the wheel with an arrow on the above diagram. [1]

(b) Calculate the magnitude of the initial force, *F*, which is just sufficient to turn the wheel so that it will rise over the step. [2]

Taking moments about pivot at P,

$W \times d_1 = F \times 0.60$

$(15.0 \text{ X } 10) \text{ X } \sqrt{(1.00^2 - 0.60^2)} = F \times 0.60$ [1]

$F$ = 200 N or $2.0 \times 10^2$ N [1]

Common mistake:

- Used *r* as perpendicular distance for *W*, instead of $d_1$