O Level Pure Physics Structured

Moments Test 1.0

Q1

Fig. 2.1 shows a student doing a push-up. A total force *F* acts upwards on his hands. There is also a force *R* upwards on his toes.

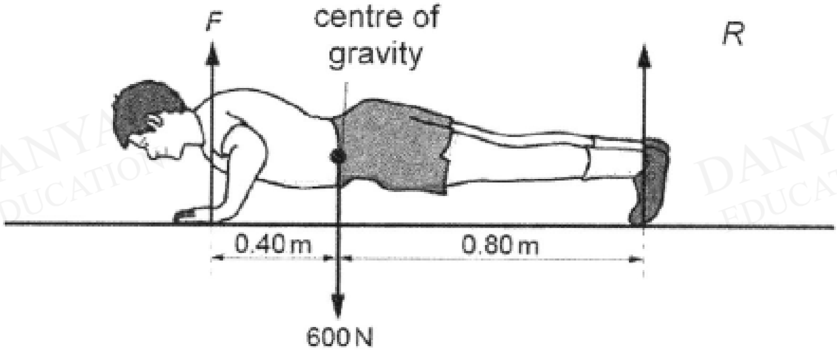


Fig. 2.1

The weight of the student is 600 N and this force acts downwards from his centre of gravity.

(a) Describe how work is done on his body as it rises from the ground.

....

.... [1]

(b) At the position shown in Fig. 2.1, the student is stationary. The weight of the student causes a moment about his toes. Calculate

(i) the moment of the weight of the student about his toes,

moment = ... [1]

(ii) the value of the forces F and R.

F = ...

R = ... [2]

(c) Describe the other force that forms a Newton's Third Law action-reaction pair with F, and state the body on which it acts.

....

....

.... [2]

Q2

Fig. 2.1 shows a hand-operated hydraulic jack used to lift up a load.

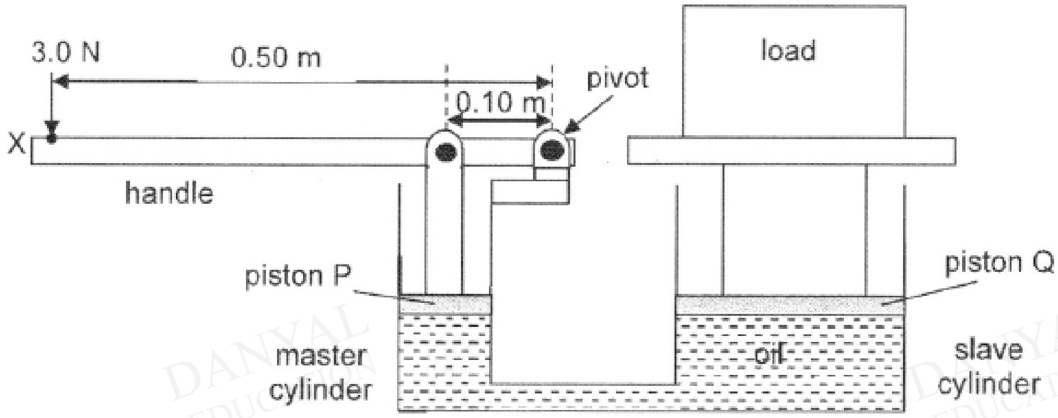


Fig. 2.1

Piston P and the handle are linked through the same pivot. When 3.0 N is applied downwards at point X, piston P in the master cylinder is pushed down with a force F_P, causing oil to flow into the slave cylinder.

(a) State the *principle of moments*.

____

____

____

____ [2]

(b) Calculate the force F_P applied directly on piston P.

F_P = ____________ [2]

(c) The area of piston P is 10 cm^2 and the area of piston Q is 200 cm^2. Calculate the load being pushed upwards by piston Q.

load = ____________ [2]

(d) If piston P moved a distance of 25 cm downwards, determine the distance moved upwards by piston Q.

distance = ____________ [2]

Q3

Fig. 2.1 shows a uniform oval disc freely pivoted at **P**. The bottom of the disc is pulled to the right by the tension in the thread **ST**.

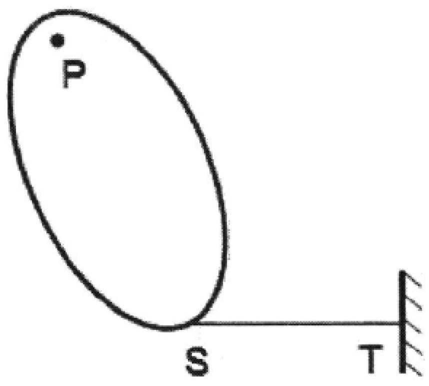


Fig. 2.1

(a) On Fig. 2.1, draw an arrow to represent

(i) the weight of the disc, marking out the position of the centre of gravity of the disc with a cross, X, [1]

(ii) the force exerted by the thread on the disc and label it as F_1, [1]

(iii) the force exerted by the pivot on the disc and label it as F_2. [1]

(b) Describe and explain what happens to the disc when the string **ST** is cut.

....

....

....[2]

Q4

Ailee wanted to lift a uniform slab on a step. She inserted the end of a 2.0 m long non-uniform metal bar under the slab and arranged the system as shown in Fig. 14.3. The weight of the metal bar is 80 N.

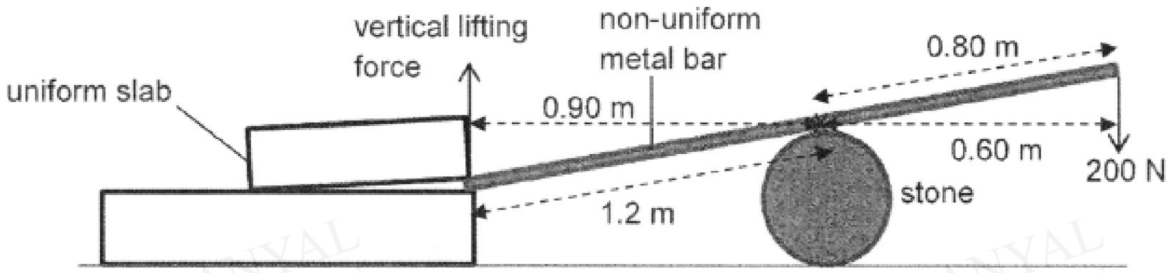


Fig. 14.3

A stone was placed such that the centre of gravity, X of the metal bar was directly above the stone. Ailee just managed to lift the metal bar by exerting a force of 200 N on the end of the bar.

(a) Define *centre of gravity*.

....

.... [1]

(b) Describe the other force that is part of the action-reaction pair with the vertical lifting force exerted on the edge of the slab.

....

.... [1]

(c) Calculate the vertical lifting force exerted on the edge of the slab.

lifting force = ... [2]

(d) Calculate the force of the stone on the bar.

force = ... [1]

(e) Calculate the weight of the uniform slab.

weight = ... [1]

(f) Suggest a way for Ailee to lift the stone slab with a force that is less than 200 N. Explain your answer.

....

....

....

.... [2]

(g) Ailee wanted to verify that the centre of gravity of the metal bar is 0.80 m from the right end of the bar.

Describe an experiment to determine the exact location of the centre of the gravity of the bar. In your account,

- set-up must be drawn and clearly labelled,
- explain how Ailee can conclude that the centre of gravity is indeed 0.80 m from the right end of the bar.

....

....

....

.... [2]

Q5

Fig. 3.1 shows a firefighter of total weight 840 N in equilibrium at the top of a ladder that is pivoted at point **P**.

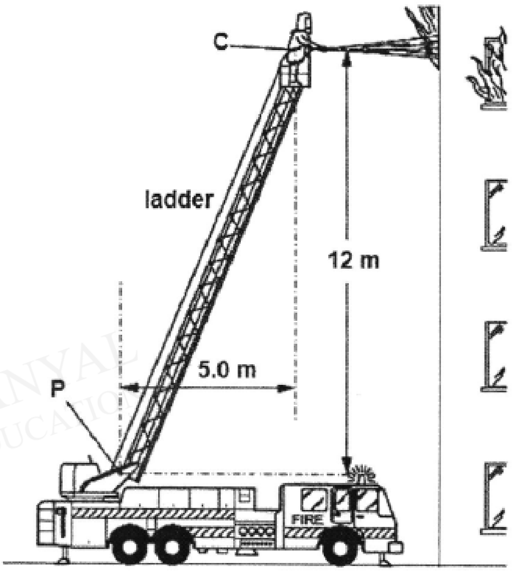


Fig. 3.1

The ladder leans towards a burning building at an angle such that the centre of gravity **C** of the firefighter is 12 m above and 5.0 m to the right of **P**. The firefighter holds a hose that directs a high-speed jet of water horizontally into a burning building.

(a) Calculate the moment *M* of the firefighter's weight about **P**.

moment *M* = ……………….. [2]

(b) The jet of water causes a horizontal force *R* on the firefighter that acts towards the left, through **C**. This opposes the turning effect of his weight. Calculate the magnitude of force *R* that, on its own, ensures that *M* is exactly cancelled.

force *R* = ……………….. [2]

(c) Suggest a third force that has a clockwise turning effect about **P** on the ladder.

…………………………………………………………………………………………………… [1]

Answers

Moments Test 1.0

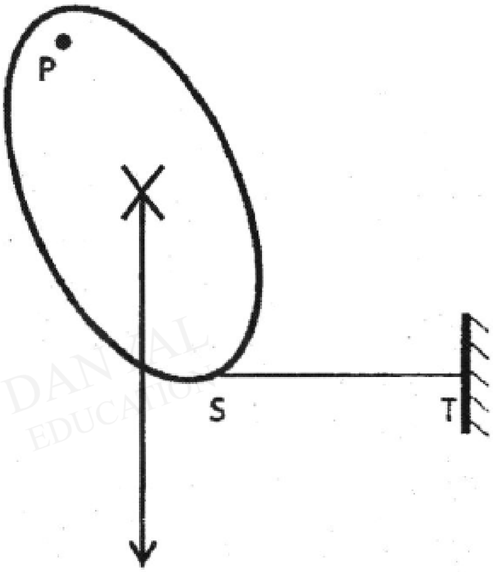
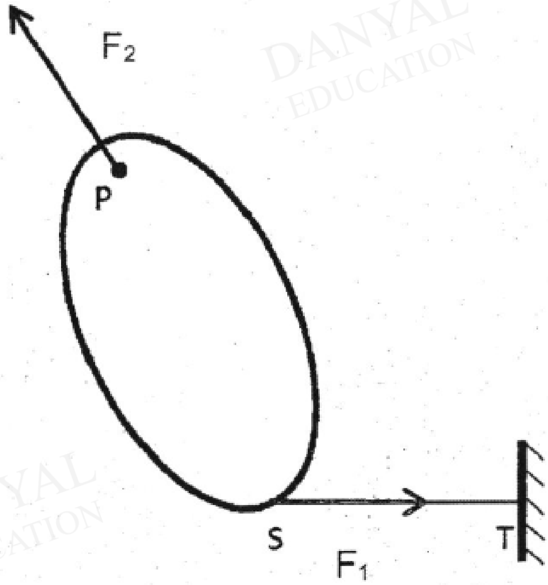
Q1

a	When he pushes the floor, his body rises and moves through a distance in the same direction as the force F, hence work is done. [B1]
bi	Moment = F x d = 600 x 0.80 = 480 Nm [A1]
bii	By Principle of Moments, F x 1.2 = 480 F = 400 N [A1] (ecf awarded) ∑ upward forces = ∑ downward forces F + R = 600 R = 200 N [A1]
c	The other force that forms an action-reaction pair with *F* is the force exerted by the boy's hand on the floor. [B1] It has an equal magnitude but acting in the opposite direction to *F*. [B1]

Q2

2(a)	Principle of Moments states that the sum of clockwise moments is equal to the sum of anticlockwise moments about the same pivot such that the system is in equilibrium.	[1] [1]
(b)	3.0 x 0.50 = Fp x 0.10 F_P = 15 N	[1] [1]
(c)	$F_P/A_P = F_Q/A_Q$ $15/10 = F_Q/200$ load = 300 N [allow ecf]	[1] [1]
(d)	work done is same at P and Q, $F_P \times D_P = F_Q \times D_Q$ $15 \times 0.25 = 300 \times D_Q$ D_Q = 0.0125 m [allow ecf]	[1] [1]

Q3

ai	 Correct position of X and arrow vertically down passing through X	B1
aii aiii		B1 B1
b	The weight of the disc will produce a moment (about the pivot) and disc will rotate clockwise OR disc will come to rest with centre of gravity directly below pivot.	B1 B1

Q4

4a	The Center of Mass/Gravity of an object is the point where the whole weight of the object appears to act for <u>any orientation of the object.</u>	1
4b	Force of slab on bar	1
4c	Force × 0.9 = 200 × 0.6 Force = 133 N	1 1
4d	Force = 133 + 80 + 200 = 413 N	1
4e	If the stone slab is 1.0 m wide, Weight × 0.5 = 133 X 1 Weight = 266 N	1
4f	• shift the stone to the left of the bar • the anticlockwise moment provided by the force of slab on bar will decrease. For the clockwise moment to decrease too, the force applied by Ailee will decrease, with a longer perpendicular distance between force and the pivot.	1 1
4g	• using a string, hang the bar at a distance of 0.80 m from the right end of the bar • if the bar is horizontal, the cg is at the pivot. The moments provided by the weight of the bar is zero.	1 1

Q5

(a)	Moments (M) = F × d = (840N)(5.0m) = **4200 Nm**	[1]: W & C/F [1]: A & U
(b)	Apply principle of moments about P: (R)(12) = (840)(5.0) Force R = **350 N**	[1]: W & C/F [1]: A & U
(c)	weight of ladder / hose / fire engine	[1]