O Level Pure Physics Structured

Moments Test 2.0

Q1

a) **Fig. 2.1** shows a child's toy. It is made of wood, in the shape of a bird. The toy includes a metal weight stuck to the tail. When placed on a metal rod, the toy balances in equilibrium.

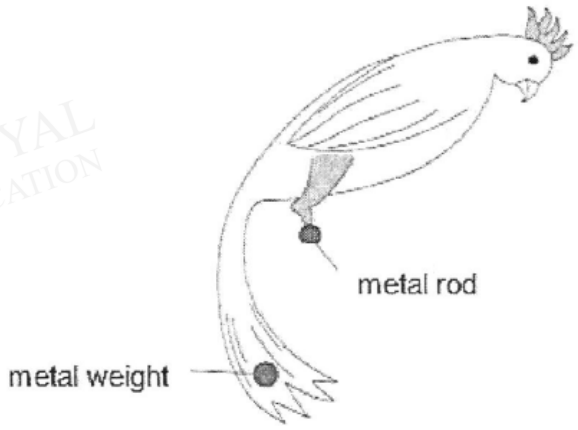


Fig 2.1

(i) Mark and label the possible position of the centre of gravity of the bird **only** on **Fig. 2.1** with a cross '**x**'. [1]

(ii) State and explain what happens to the toy immediately after the metal weight falls off. [1]

……

……

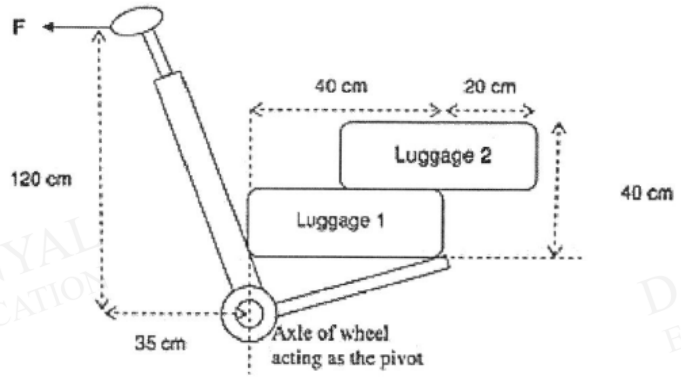
……

……

……

……

b) An airplane passenger places two identical luggages, each of mass 15 kg, onto a trolley as shown in the diagram. The centre of gravity of each luggage is in the middle of each luggage. He applies a force **F** at the handle to raise the luggages to the horizontal position shown.



(i) Calculate the force **F** applied at the handle to keep the luggage horizontal. [2]

Force F =.....

(ii) The airplane passenger wheels the trolley as shown in the diagram for a distance of 150 m. The frictional force on the trolley is 25 N. What is the useful work done by passenger? [2]

Useful work done =.....

(iii) If the airplane passenger let go of the handle, the trolley will become upright. What will happen to **luggage 1** and **2**? Explain your answer. [3]

.....

.....

.....

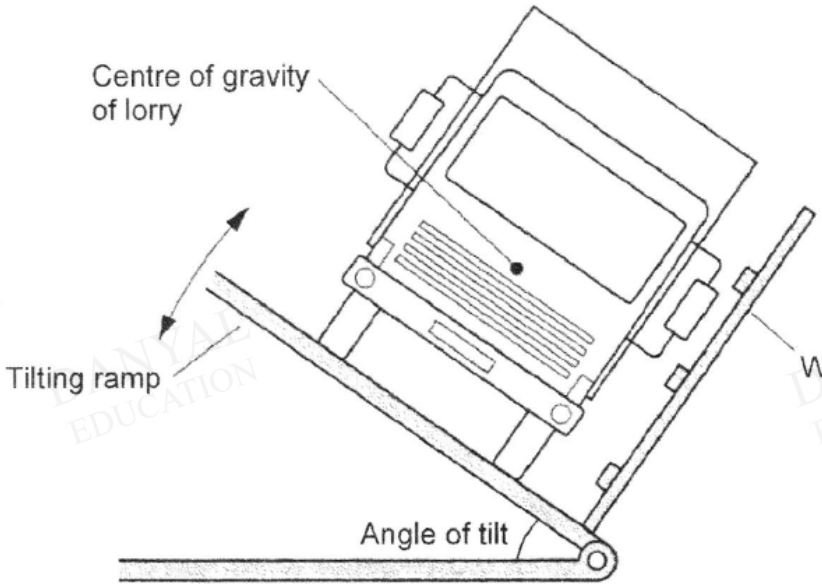
.....

.....

.....

Q2

The stability of a lorry of weight 50 000 N is tested as shown below.



The ramp is titled as much as possible without the lorry falling over. The ramp is then fixed and the lorry remains at rest in the position as shown above.

(a) Explain why the lorry falls over if the ramp is tilted any further.

.....

.....

.....

..... [2]

(b) State how the position of the centre of gravity of the lorry affects the angle of tilt of the ramp.

.....

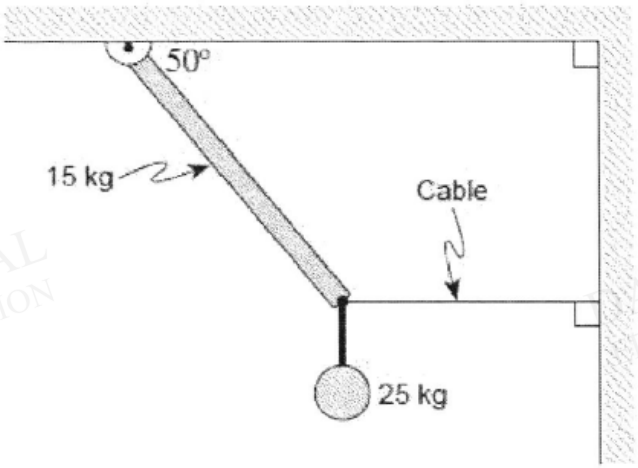
..... [1]

(c) Given that the lorry has six wheels and each wheel has a contact area of 0.058 m^2 with the ground, calculate the contact pressure of each wheel assuming the weight of the lorry is evenly distributed among the wheels.

Contact pressure of a wheel = ... [2]

Q3

A 4.0 m long uniform pole with a mass of 15 kg is pivoted at one end and held in position by a horizontal cable at the other end. A 25 kg mass is suspended from the end of the pole as shown in the figure below.



a. Calculate the weight of the uniform pole.

[1]

b. Mark out clearly, on the figure, the position where all the weight of the pole seems to be acting.

[1]

c. Determine the tension in the horizontal cable.

[2]

Q4

Fig. 1.1 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.

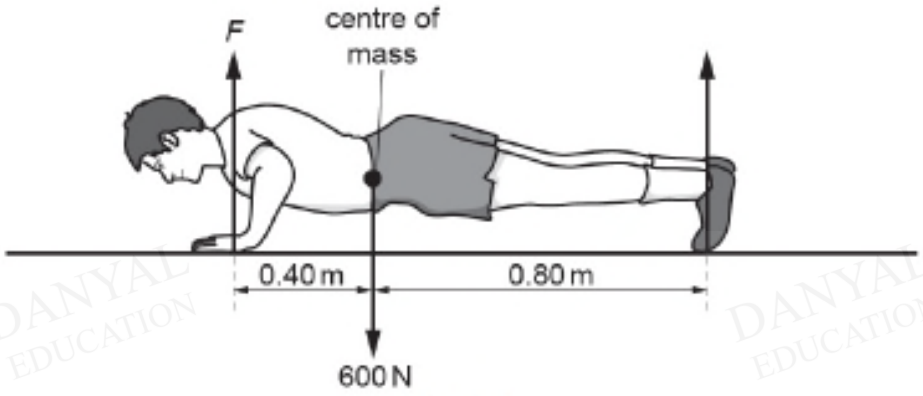


Fig. 1.1

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

(a) **(i)** Describe how the student does work as his body rises from the ground.

_____

_____ [1]

(ii) State the form of energy that the student uses to do this work.

_____ [1]

(b) At the position shown in Fig. 1.1, the student is stationary. The weight of the student causes a moment about his toes.

(i) Calculate the moment of the weight of the student about his toes.

moment = _____ [1]

(ii) Calculate 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]

Q5

(a) State the principle of moments.

.....

.....

..... [2]

(b) Fig. 4.1 shows a simplified diagram of the handbrake lever of a car. Distances are marked on Fig. 4.1.

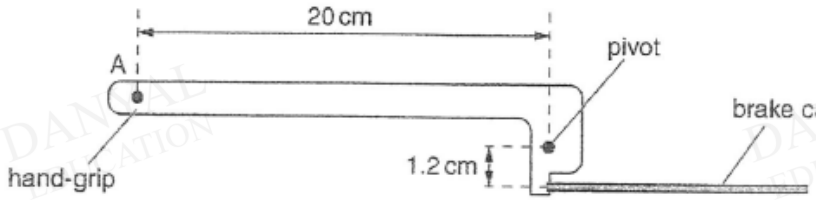


Fig. 4.1 (not to scale)

A force of 30 N is applied by the car driver at point A.

(i) Describe how, with a 30 N force at A, the driver can produce the largest moment about the pivot.

.....

..... [1]

(ii) Calculate the largest moment of this force about the pivot.

moment = ... [2]

(iii) Calculate the largest force in the cable brake.

force = ... [1]

Answers

Moments Test 2.0

Q1

a) **Fig. 2.1** shows a child's toy. It is made of wood, in the shape of a bird. The toy includes a metal weight stuck to the tail. When placed on a metal rod, the toy balances in equilibrium.

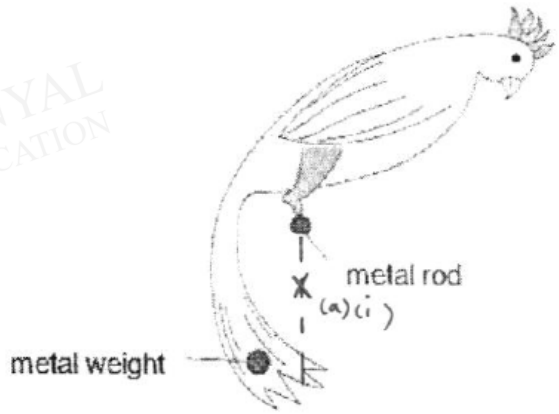


Fig 2.1

(i) Mark and label the possible position of the centre of gravity of the bird **only** on **Fig. 2.1** with a cross '**x**'. [1]

(ii) State and explain what happens to the toy immediately after the metal weight falls off. [1]

The toy bird rotates clockwise about the metal rod, and falls off the rod.

After the metal weight fell off, the toy bird will be in dis-equilibrium. The weight of the toy bird will produce a clockwise moment about the pivot on the metal rod, causing the toy to rotate clockwise until it fell off the rod.

(i) Calculate the force **F** applied at the handle to keep the luggage horizontal. [2]

Anti-clockwise moment = clockwise moment

$F \times 120 = 150 \times 20 + 150 \times 40$

$F = 75\ N$

Force F = 75 N

(ii) The airplane passenger wheels the trolley as shown in the diagram for a distance of 150 m. The frictional force on the trolley is 25 N. What is the useful work done by passenger? [2]

Useful Work Done = WD by horizontal force F − WD by frictin

$= 75 \times 150 - 25 \times 150$

$= 7500\ J$

Useful work done = 7500 J

(iii) If the airplane passenger let go of the handle, the trolley will become upright. What will happen to **luggage 1** and **2**? Explain your answer. [3]

Luggage 1 will remain on the trolley, while luggage 2 will topple off the trolley.

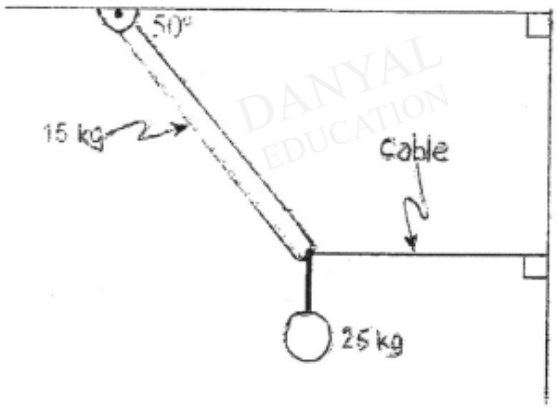
When trolley become upright, the clockwise moment on Luggage 1 is still equal to the anti-clockwise moment on it, so it is in stable equilibrium and will not topple; while the clockwise moment acting on luggage 2 is more than the anti-clockwise moment, so it rotates clockwise and fell off the trolley.

Q2

4a	If the ramp is tilted any further, the **vertical line through centre of gravity of the lorry will lie outside its base [1].** The **weight of the lorry will cause a clockwise moment about the side of the lorry closer to the wall [1]**, causing the lorry to fall over.	[2]
4b	The lower the centre of gravity, the larger the angle of tilt. *OR* The higher the centre of gravity, the smaller the angle of tilt.	[1]
4c	$p = \frac{F}{A} = \frac{50000}{6 \times 0.058} \approx 140000$ Pa (2 or 3 s.f)	Working [1] Ans [1]

Q3

A 4.0 m long uniform pole with a mass of 15 kg is pivoted at one end and held in position by a horizontal cable at the other end. A 25 kg mass is suspended from the end of the pole as shown in the figure below.



a. Calculate the weight of the uniform pole.

[1]

W = mg

W = 15 x 10

W = 150 N *A1*

b. Mark out clearly, on the figure, the position where all the weight of the pole seem to be acting.

[1]

c. Determine the tension in the horizontal cable.

[2]

Using Principle of Moments

$T \times 4 \cos 40^0 = 250 \times 4 \sin 40^0 + 150 \times 2 \sin 40^0$ *A1*

$T = 272$ N *A1*

Q4

(a)	**(i)**	When he pushes the floor, his body rises and moves through a distance in the same direction as the force, hence work is done.	[1]	
	(ii)	Chemical (potential) energy	[1]	
(b)	**(i)**	Moment = F x d = 600 x 0.80 = 480 Nm	[1]	**No credit for wrong/ missing unit.**
	(ii)	By Principle of Moments, F x 1.2 = 480 F = 400 N ∑ upward forces = ∑ downward forces F + R = 600 R = 200 N	[1] [1]	Alternatively, Principle of Moments can be used to solve for R. Max [1] ecf if F is wrongly calculated.
(c)		The other force that forms an action-reaction pair with *F* is the force exerted by the boy on the floor. It has an equal magnitude but acting in the opposite direction to *F*.	[1] [1]	

Q5

(a)
When an object is in equilibrium, the sum of anti-clockwise moments about a pivot is equal to the sum of clockwise moments about the same pivot.

Mention moments are equal to – award 1m
Mention the same pivot – award 1m
Did not mention "sum of" – deduct 1m
Did not mention "about a point/ pivot" – deduct 1m

(bi)
The 30 N force is exerted at a location which has the longest perpendicular distance from the pivot to the force, hence producing the largest moment about the pivot.

(bii)
moment = F x perpendicular distance
= 30 x 0.20
= 6.0 Nm
OR
moment = F x perpendicular distance
= 30 x 20
= 600 Ncm

(biii)
moment = F x perpendicular distance
600 = F in the brake cable x 1.2
F in brake cable = 500 N