Questions compiled by Leong Yee Pak

Forces

5.1 Types of force

**1 June 02 P1 Q12

12 A submarine descends vertically at constant velocity. The three forces acting on the submarine are viscous drag, upthrust and weight.
Which relationship between their magnitudes is correct?

A weight < drag

B weight = drag

C weight < upthrust

D weight > upthrust

**2 June 02 P1 Q14

A cylindrical block of wood has a cross-sectional area A and weight W. It is totally immersed in water with its axis vertical. The block experiences pressures p_t and p_b at its top and bottom surfaces respectively.

Which of the following expressions is equal to the upthrust on the block?

A $(p_b - p_t)A + W$

B $(p_b - p_t)$

C $(p_b - p_t)A$

D $(p_b - p_t)A - W$

*3 June 04 P1 Q12

An object, immersed in a liquid in a tank, experiences an upthrust.

What is the physical reason for this upthrust?

A The density of the body differs from that of the liquid.

B The density of the liquid increases with depth.

C The pressure in the liquid increases with depth.

D The value of g in the liquid increases with depth.

1
Questions compiled by Leong Yee Pak
Forces
5.1 Types of force
5.2 Equilibrium of forces
5.3 Centre of gravity
5.4 Turning effects of forces
5.1 Types of force

[Type text] Compiled by Leong Yee Pak [Type text]

***4 Nov 06 P1 Q13**

13 Which force is caused by a pressure difference?

A friction

B upthrust

C viscous force

D weight

****5 June 08 Q12**

12 A ball is falling at terminal speed in still air. The forces acting on the ball are upthrust, viscous drag and weight.

What is the order of increasing magnitude of these three forces?

A upthrust → viscous drag → weight

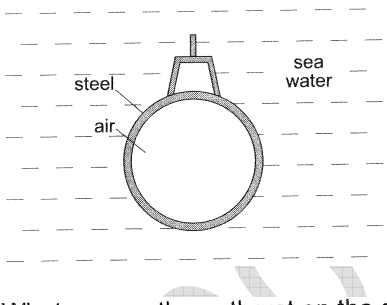
B viscous drag → upthrust → weight

C viscous drag → weight → upthrust

D weight → upthrust → viscous drag

***6 June 08 Q15**

15 A submarine is in equilibrium in a fully submeged position.



What causes the upthrust on the submarine?

A The air in the submarine is less dense than sea water.

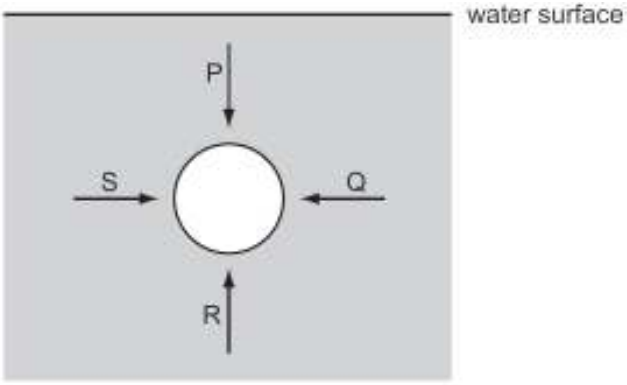
B The sea water exerts a greater upward force on the submarine than the weight of the steel.

C The submarine displaces its own volume of sea water.

D There is a difference in water pressure acting on the top and bottom of the submarine.

***7 June 09 P2 Q11**

11 The diagram represents a sphere under water. P, Q, R, and S are forces acting on the sphere, due to the pressure of the water.



Each force acts perpendicularly to the sphere's surface. P and R act in opposite directions vertically. Q and S act in opposite directions horizontally.
Which information about the magnitudes of the forces is correct?

A P < R ; S = Q

B P > R ; S = Q

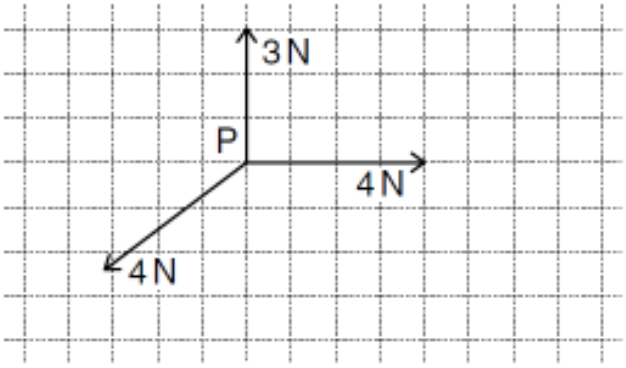
C P = R ; S = Q

D P = R = S = Q

5.2 Equilibrium of forces

*****1 June 02 P1Q15**

15 The vector diagram shows three coplanar forces acting on an object at P.



The magnitude of the resultant of these three forces is 1 N.

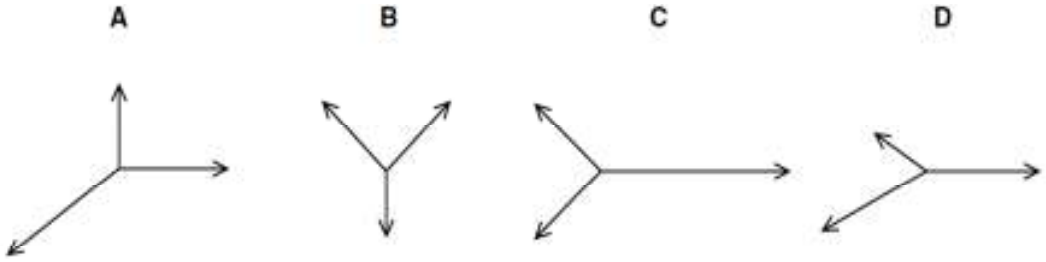
What is the direction of this resultant?

A ↓ **B** ↘ **C** ↙ **D** ↗

*****2 Nov 02 P1 Q15**

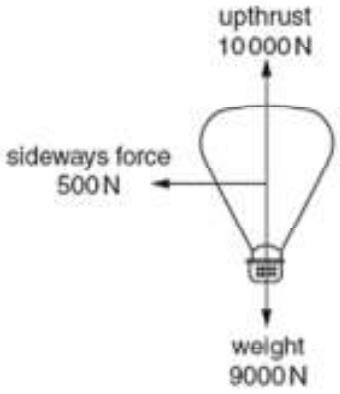
15 The diagrams represent systems of coplanar forces acting at a point. The lengths of the force vectors represent the magnitudes of the forces.
Which system of forces is in equilibrium?

4



**3 June 03 P1 Q14

A balloon is acted upon by three forces, weight, upthrust and sideways force due to the wind, as shown in the diagram.



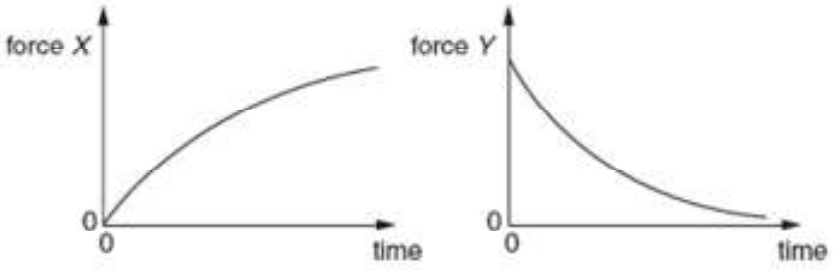
What is the vertical component of the resultant force on the balloon?

A 500N B 1000N C 10 000N D 10500N

**4 June 03 P1 Q15

A ball falls from rest through air and eventually reaches a constant velocity.

For this fall, forces *X* and *Y* vary with time as shown.



What are forces *X* and *Y*?

	force *X*	force *Y*
A	air resistance	resultant force
B	air resistance	weight
C	upthrust	resultant force
D	upthrust	weight

****5 Nov 03 P1 Q15**

A force *F* is applied to a freely moving object. At one instant of time, the object has velocity *v* and acceleration *a*.

Which quantities **must** be in the same direction?

A *a* and *v* only

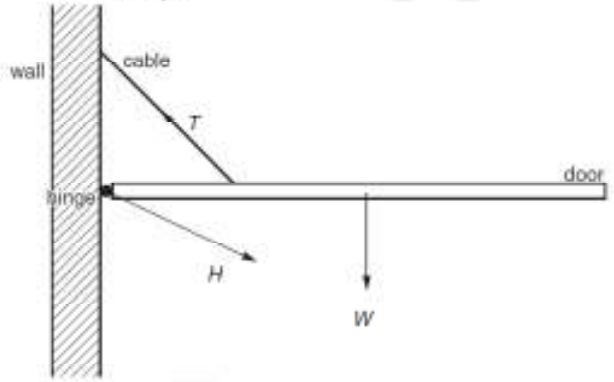
B *a* and *F* only

C *v* and *F* only

D *v*, *F* and *a*

*****6 Nov 03 P1 Q16**

16 A hinged door is held closed in the horizontal position by a cable.
Three forces act on the door: the weight *W* of the door, the tension *T* in the cable, and the force *H* at the hinge.

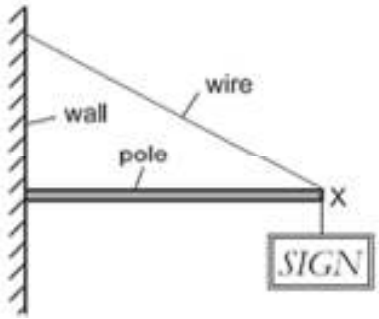


Which list gives the three forces in **increasing** order of magnitude?

A *H*,*T*,*W** **B** *T*,*H*,*W** **C** *W*,*H*,*T** **D** *W*,*T*,*H*

***7 June 04 P1 Q14**

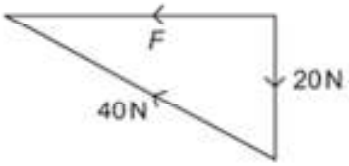
The diagram shows a sign of weight 20 N suspended from a pole, attached to a wall. The pole is kept in equilibrium by a wire attached at point X of the pole.



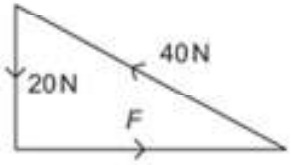
The force exerted by the pole at point X is *F*, and the tension in the wire is 40 N.

Which diagram represents the three forces acting at point X?

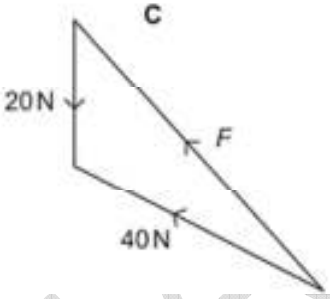
A



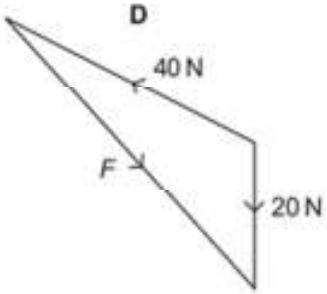
B



C

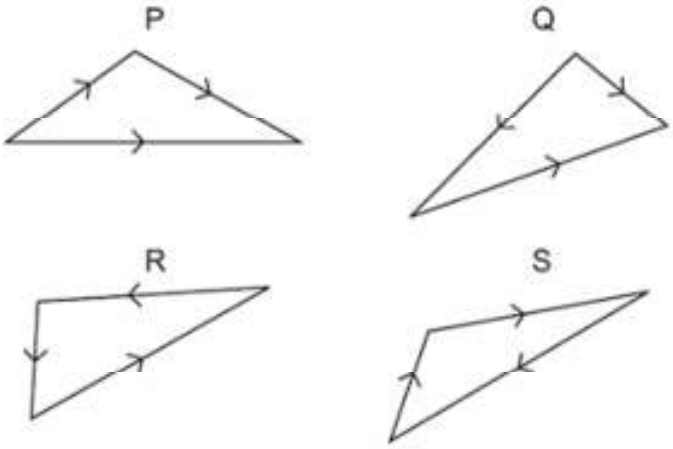


D



***8 June 05 P1Q12**

Which two vector diagrams represent forces in equilibrium?



A P and Q

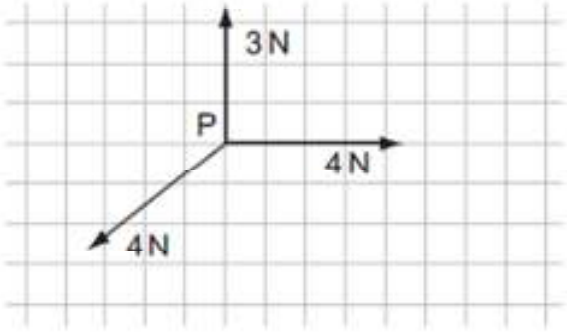
B Q and R

C R and S

D S and P

*****9 June 05 P1 Q14**

The vector diagram shows three coplanar forces acting on an object at P.



The magnitude of the resultant of these three forces is 1N.

What is the direction of this resultant?

A ↓ **B** ↘ **C** ↙ **D** ↗

***10 June 06 P1 Q13**

13 The diagrams show three forces acting on a body.

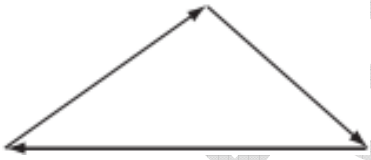
In which diagram is the body in equilibrium?

A

B

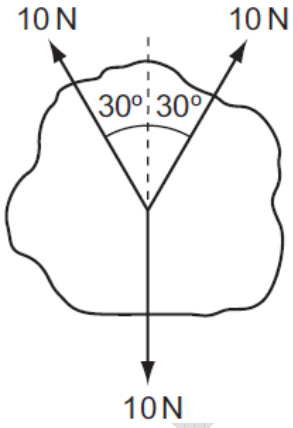
C

D



****11 Nov 06 P1 Q15**

15 Three coplanar forces, each of magnitude 10 N, act through the same point of a body in the directions shown.

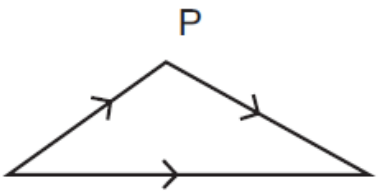


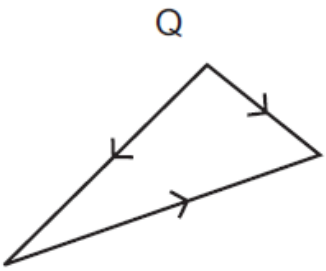
What is the magnitude of the resultant force?

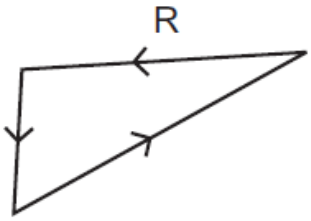
A 0 N **B** 1.3 N **C** 7.3 N **D** 10 N

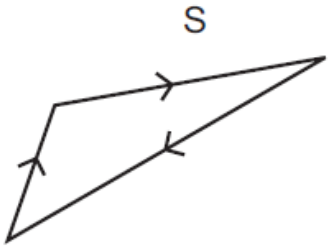
***12 June 07 P1 Q13**

13 Which two vector diagrams represent forces in equilibrium?









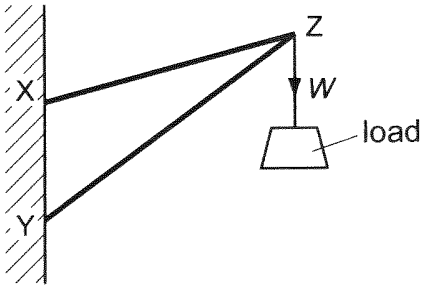
A P and Q **B** Q and R **C** R and S **D** S and P

***13 June 08 P1 Q13**

13 Two rigid rods, XZ and YZ, are fixed to a vertical wall at points X and Y.

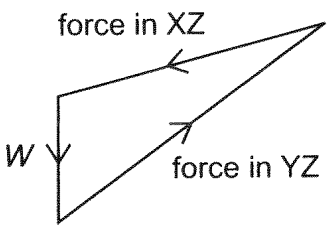
A load of weight *W* is hung from point Z.

The load is not moving.

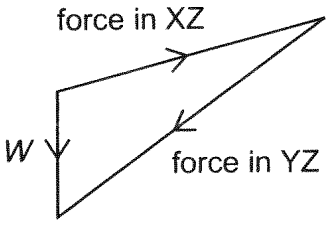


Which diagram shows the forces acting at point Z?

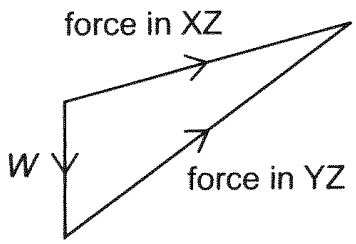
A



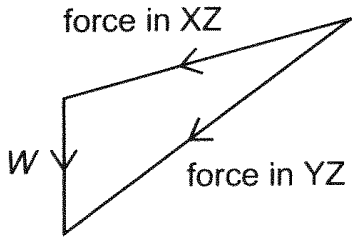
B



C



D



**14 June 09 P2 Q12

12 An object, made from two equal masses joined by a light rod, falls with uniform speed through air.

The rod remains horizontal.
Which statement about the equilibrium of the system is correct?

A It is not in equilibrium because it is falling steadily.

B It is not in equilibrium because it is in motion.

C It is not in equilibrium because there is a resultant torque.

D It is in equilibrium because there is no resultant force and no resultant torque.

Section B

June 06 P2 Q2

2 A rod AB is hinged to a wall at A. The rod is held horizontally by means of a cord BD, attached to the rod at end B and to the wall at D, as shown in Fig. 2.1.

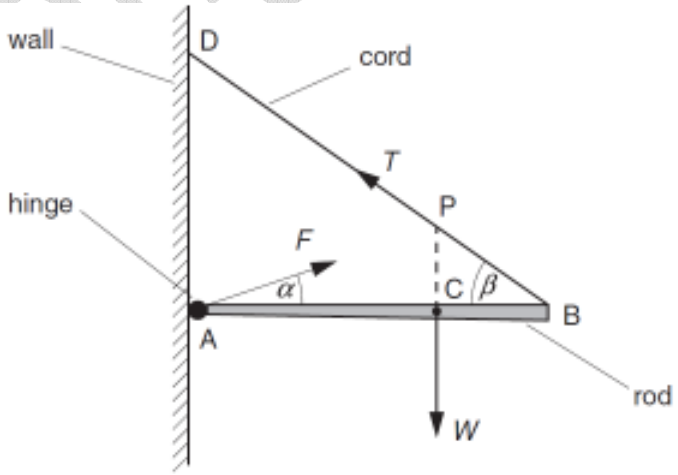


Fig. 2.1

The rod has weight *W* and the centre of gravity of the rod is at C. The rod is held in equilibrium by a force *T* in the cord and a force *F* produced at the hinge.

(a) Explain what is meant by

(i) the *centre of gravity* of a body,

.....

.....

..... [2]

(ii) the *equilibrium* of a body.

.....

.....

.....

..... [2]

(b) The line of action of the weight W of the rod passes through the cord at point P. Explain why, for the rod to be in equilibrium, the force F produced at the hinge must also pass through point P.

.....

.....

.....

..... [2]

(c) The forces F and T make angles α and β respectively with the rod and AC = $\frac{2}{3}$AB, as shown in Fig. 2.1.

Write down equations, in terms of F, W, T, α and β, to represent

(i) the resolution of forces horizontally,

..... [1]

(ii) the resolution of forces vertically,

..... [1]

(iii) the taking of moments about A.

..... [1]

12

5.3 Centre of gravity
5.4 Turning effects of forces

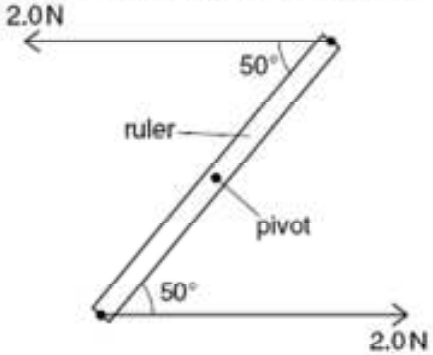
5.3 Centre of gravity
5.4 Turning effects of forces

Section A

Section A

**1 June 02 P1 Q13

A ruler of length 0.30 m is pivoted at its centre. Equal and opposite forces of magnitude 2.0 N are applied to the ends of the ruler, creating a couple as shown.



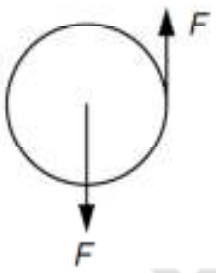
What is the magnitude of the torque of the couple on the ruler when it is in the position shown?

A 0.23 Nm **B** 0.39 Nm **C** 0.46 Nm **D** 0.60 Nm

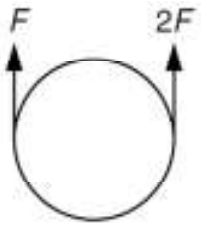
**2 Nov 02 P1 Q13

13 Which of the following pairs of forces, acting on a circular object, constitutes a couple?

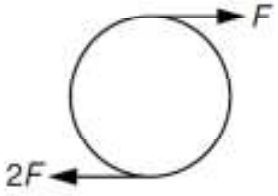
A



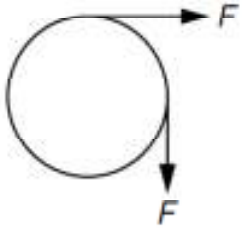
B



C



D



***3 Nov 02 P1 Q14

14 A uniform metre rule of mass 100 g is supported by a knife-edge at the 40 cm mark and a string at the 100 cm mark. The string passes round a frictionless pulley and carries a mass of 20 g as shown in the diagram.

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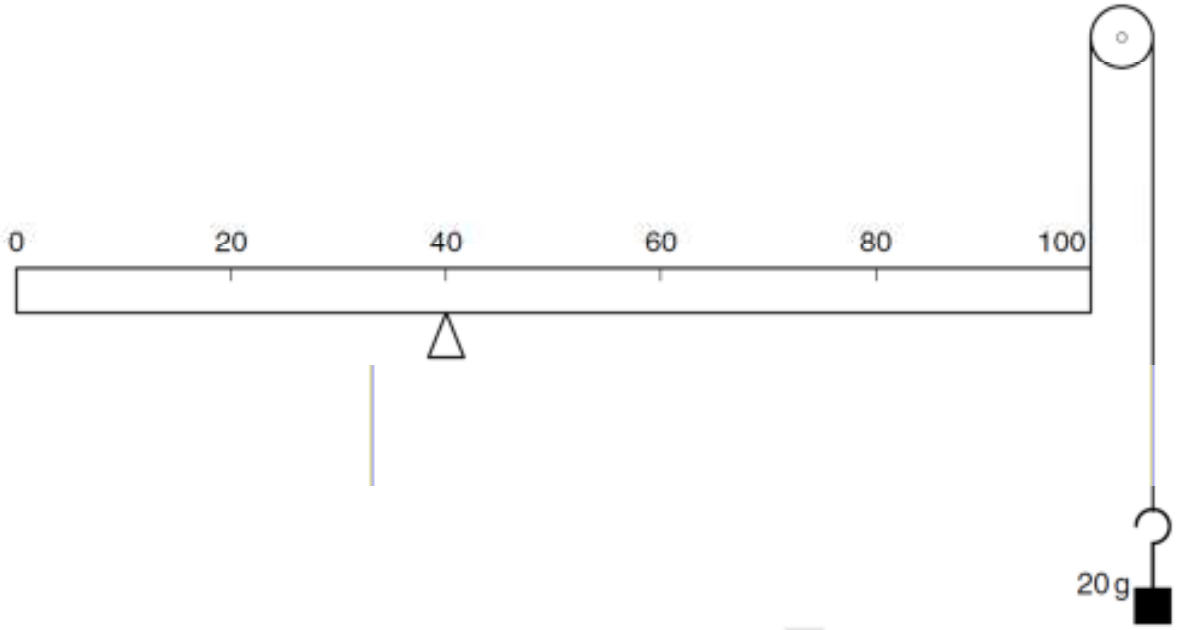
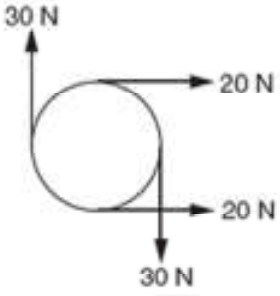


At which mark on the rule must a 50 g mass be suspended so that the rule balances?

A 4 cm **B** 36 cm **C** 44 cm **D** 96 cm

****4 June 03 P1 Q13**
The diagram shows four forces applied to a circular object.

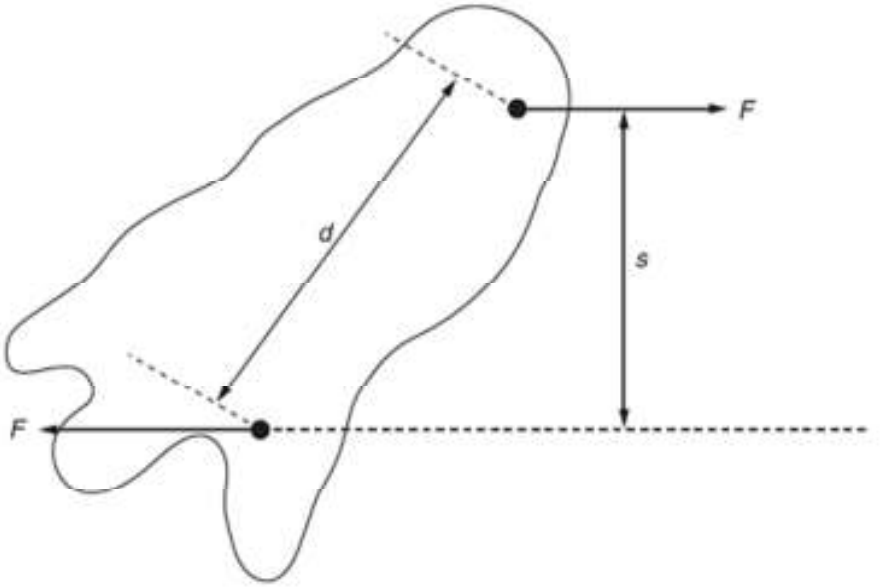


Which of the following describes the resultant force and resultant torque on the object?

	resultant force	resultant torque
A	zero	zero
B	zero	non-zero
C	non-zero	zero
D	non-zero	non-zero

**5 Nov 03 P1 Q14

Two parallel forces, each of magnitude *F*, act on a body as shown.

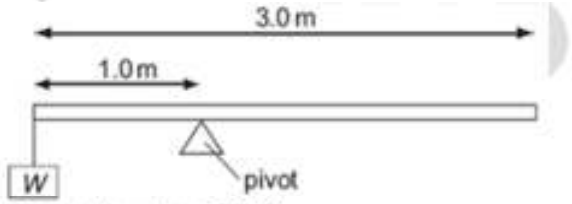


What is the magnitude of the torque on the body produced by these forces?

A *Fd* **B** *Fs* **C** *2Fd* **D** *2Fs*

***6 June 04 P1 Q13

A uniform beam of weight 50 N is 3.0 m long and is supported on a pivot situated 1.0 m from one end. When a load of weight *W* is hung from that end, the beam is in equilibrium, as shown in the diagram.

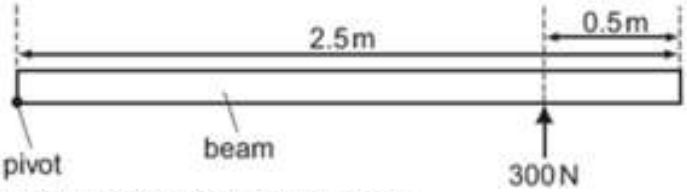


What is the value of *W*?

A 25 N **B** 50 N **C** 75 N **D** 100 N

**7 June 05 P1 Q13

A long uniform beam is pivoted at one end. A force of 300 N is applied to hold the beam horizontally.



What is the weight of the beam?

A 300 N **B** 480 N **C** 600 N **D** 960 N

***8 June 05 P1 Q14**

What is the centre of gravity of an object?

A the geometrical centre of the object

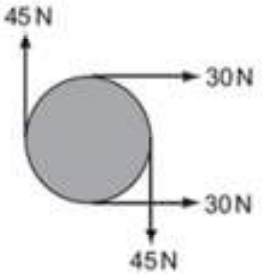
B the point about which the total torque is zero

C the point at which the weight of the object may be considered to act

D the point through which gravity acts

****9 Nov 05 P1 Q13**

The diagram shows four forces applied to a circular object.

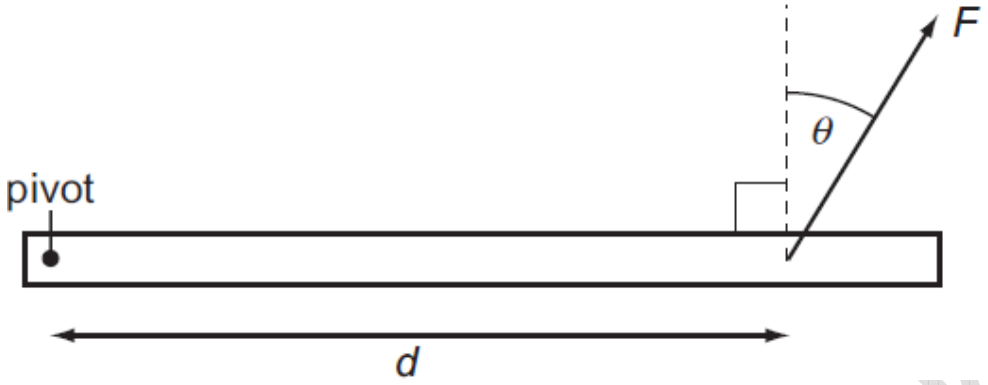


Which of the following describes the resultant force and resultant torque on the object?

	resultant force	resultant torque
A	non-zero	non-zero
B	non-zero	zero
C	zero	non-zero
D	zero	zero

*****10 June 06 P1 Q14**

14 A force *F* is applied to a beam at a distance *d* from a pivot. The force acts at an angle θ to a line perpendicular to the beam.

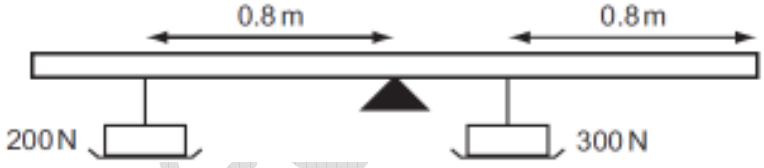


Which combination will cause the largest turning effect about the pivot?

	F	*d*	θ
A	large	large	large
B	large	large	small
C	small	small	large
D	small	large	small

***11 June 06 P1 Q15**

15 A rigid uniform bar of length 2.4 m is pivoted horizontally at its mid-point.



Weights are hung from two points of the bar as shown in the diagram. To maintain horizontal equilibrium, a couple is applied to the bar.

What is the torque and direction of this couple?

A 40 N m clockwise

B 40 N m anticlockwise

C 80 N m clockwise

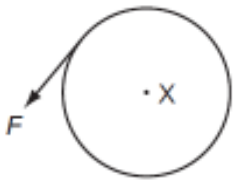
D 80 N m anticlockwise

12 Nov 06 P1 Q14

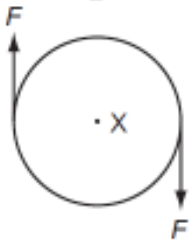
14 A rigid circular disc of radius *r* has its centre at X. A number of forces of equal magnitude *F* act at the edge of the disc. All the forces are in the plane of the disc.

Which arrangement of forces provides a moment of magnitude $2Fr$ about X?

A



B



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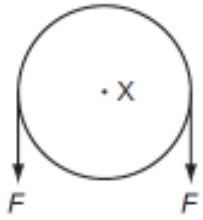
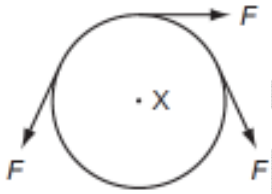
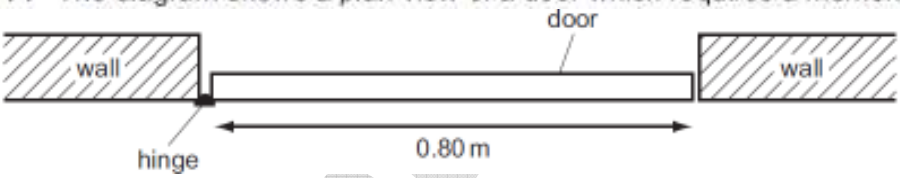


D



****13 June 07 P1 Q14**

14 The diagram shows a plan view of a door which requires a moment of 12 N m to open it.



What is the minimum force that must be applied at the door's midpoint to ensure it opens?

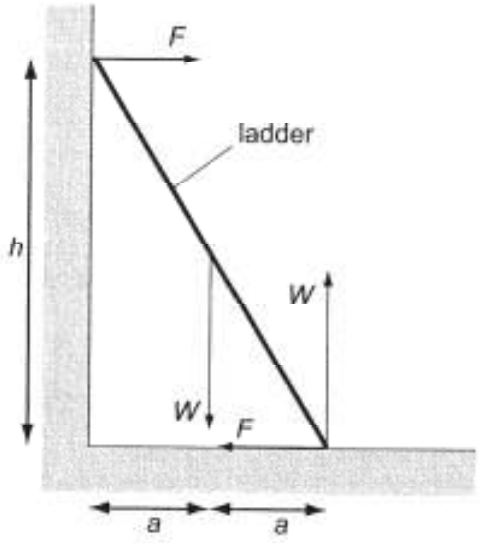
A 4.8 N **B** 9.6 N **C** 15 N **D** 30 N

*****14 June 08 P1 Q14**

14 A uniform ladder rests against a vertical wall where there is negligible friction. The bottom of the ladder rests on rough ground where there is friction. The top of the ladder is at a height *h* above the ground and the foot of the ladder is at a distance $2a$ from the wall.

The diagram shows the forces which act on the ladder.

18



Which equation is formed by taking moments?

A $Wa + Fh = 2Wa$

B $Fa + Wa = Fh$

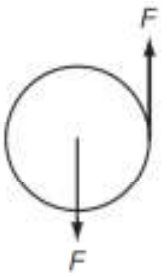
C $Wa + 2Wa = Fh$

D $Wa - 2Wa = 2Fh$

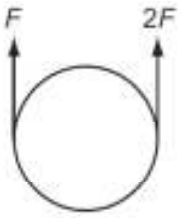
***15 Nov 08 P2 Q14**

14 Which pair of forces acts as a couple on the circular object?

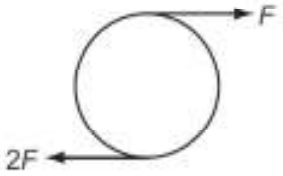
A



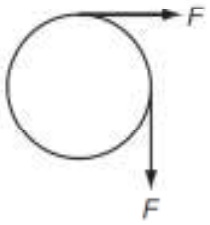
B



C



D



*****16 June 09 P2 Q13**

13 A spindle is attached at one end to the centre of a lever 1.20 m long and at its other end to the centre of a disc of radius 0.20 m. A cord is wrapped round the disc, passes over a pulley and is attached to a 900 N weight.

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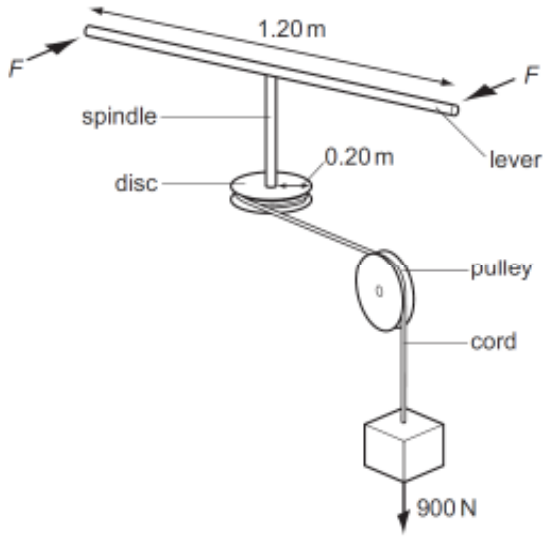

What is the minimum force *F*, applied to each end of the lever, that could lift the weight?

A 75 N **B** 150 N **C** 300 N **D** 950 N

Section B

June 02 P2 Q3

3 **(a)** Explain what is meant by the *centre of gravity* of an object.

.....

.....

.....[2]

(b) A non-uniform plank of wood XY is 2.50 m long and weighs 950 N. Force-meters (spring balances) A and B are attached to the plank at a distance of 0.40 m from each end, as illustrated in Fig. 3.1.

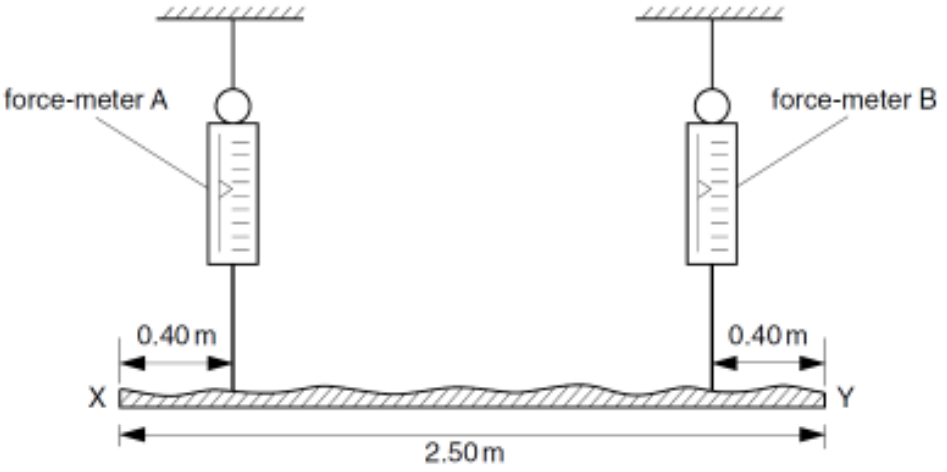

Fig. 3.1

When the plank is horizontal, force-meter A records 570 N.

(i) Calculate the reading on force-meter B.

reading = ... N

(ii) On Fig. 3.1, mark a likely position for the centre of gravity of the plank.

(iii) Determine the distance of the centre of gravity from the end X of the plank.

distance = ... m

[6]

Nov 03 P2 Q3

3 (a) Define the *moment* of a force.

.....

..... [2]

(b) State the two conditions necessary for a body to be in equilibrium.

1. .....

.....

2. .....

..... [2]

(c) Two parallel strings S_1 and S_2 are attached to a disc of diameter 12 cm, as shown in Fig. 3.1.

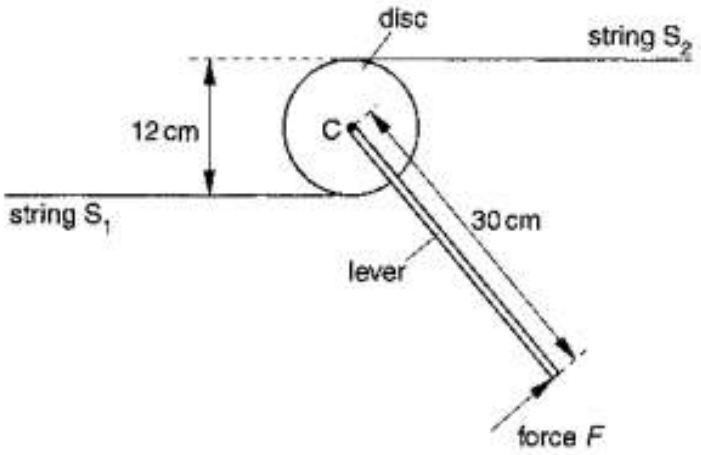

Fig. 3.1

The disc is free to rotate about an axis normal to its plane. The axis passes through the centre C of the disc.

A lever of length 30 cm is attached to the disc. When a force F is applied at right angles to the lever at its end, equal forces are produced in S_1 and S_2. The disc remains in equilibrium.

(i) On Fig. 3.1, show the direction of the force in each string that acts on the disc. [1]

(ii) For a force F of magnitude 150 N, determine

1. the moment of force F about the centre of the disc,

moment = ... N m

2. the torque of the couple produced by the forces in the strings,

torque = ... N m

3. the force in S_1.

force = ... N
[4]

June 04 P2 Q5

5 Two forces, each of magnitude *F*, form a couple acting on the edge of a disc of radius *r*, as shown in Fig. 5.1.

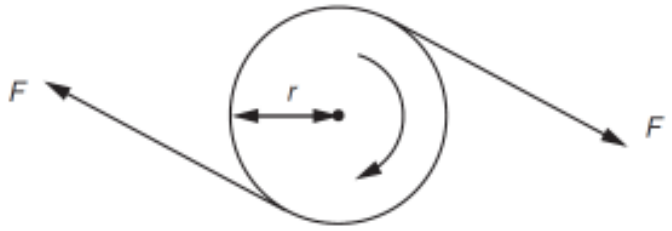

Fig. 5.1

(a) The disc is made to complete *n* revolutions about an axis through its centre, normal to the plane of the disc. Write down an expression for

(i) the distance moved by a point on the circumference of the disc,

distance = ...

(ii) the work done by one of the two forces.

work done = ...
[2]

(b) Using your answer to **(a)**, show that the work *W* done by a couple producing a torque *T* when it turns through *n* revolutions is given by

$$W = 2\pi nT.$$ [2]

23

(c) A car engine produces a torque of 470 N m at 2400 revolutions per minute. Calculate the output power of the engine.

power = ... W [2]

5 Nov 05 P2 Q2

2 (a) Explain what is meant by the *centre of gravity* of a body.

.....

.....

..... [2]

(b) An irregularly-shaped piece of cardboard is hung freely from one point near its edge, as shown in Fig. 2.1.

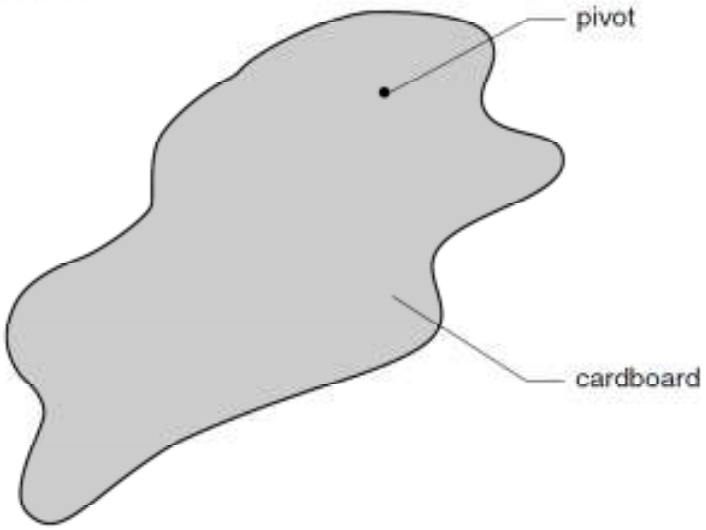

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Fig. 2.1

Explain why the cardboard will come to rest with its centre of gravity vertically below the pivot. You may draw on Fig. 2.1 if you wish.

.....

.....

..... [2]

Nov 08 P2 Q3

3 **(a)** Distinguish between the moment of a force and the torque of a couple.

moment of a force .....

.....

.....

torque of a couple .....

.....

.....

[4]

(b) One type of weighing machine, known as a steelyard, is illustrated in Fig. 3.1.

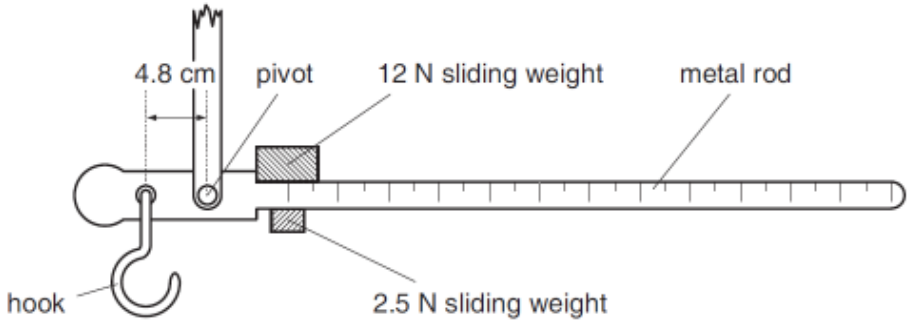

Fig. 3.1

The two sliding weights can be moved independently along the rod.

With no load on the hook and the sliding weights at the zero mark on the metal rod, the metal rod is horizontal. The hook is 4.8 cm from the pivot.
A sack of flour is suspended from the hook. In order to return the metal rod to the horizontal position, the 12 N sliding weight is moved 84 cm along the rod and the 2.5 N weight is moved 72 cm.

(i) Calculate the weight of the sack of flour.

weight = ...N [2]

(ii) Suggest why this steelyard would be imprecise when weighing objects with a weight of about 25 N.

.....

.....[1]

June 09 P2 Q3

3 **(a)** Define the *torque* of a couple.

.....

.....

..... [2]

(b) A torque wrench is a type of spanner for tightening a nut and bolt to a particular torque, as illustrated in Fig. 3.1.

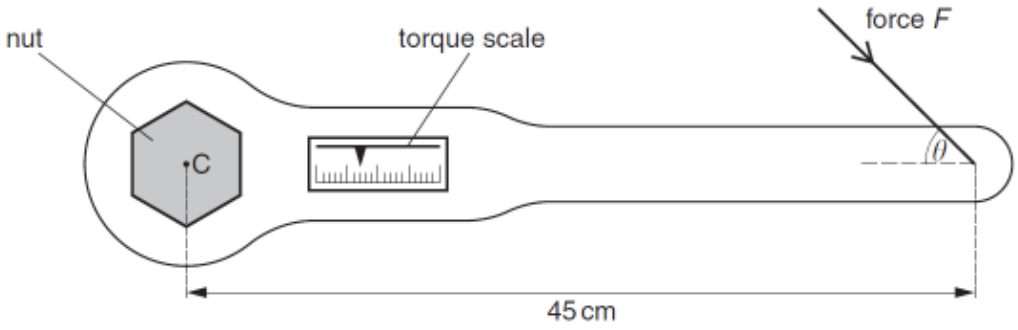

Fig. 3.1

The wrench is put on the nut and a force is applied to the handle. A scale indicates the torque applied.

The wheel nuts on a particular car must be tightened to a torque of 130 N m. This is achieved by applying a force F to the wrench at a distance of 45 cm from its centre of rotation C. This force F may be applied at any angle θ to the axis of the handle, as shown in Fig. 3.1.

For the minimum value of F to achieve this torque,

(i) state the magnitude of the angle θ that should be used,

θ = ... ° [1]

(ii) calculate the magnitude of F.

F = ... N [2]