4. Forces, Density and Pressure

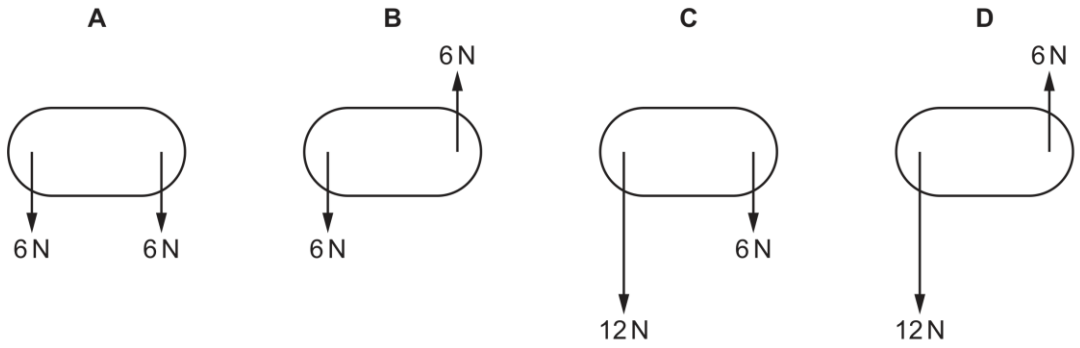
4.1 Turning effects of forces

Paper 1

Question Paper

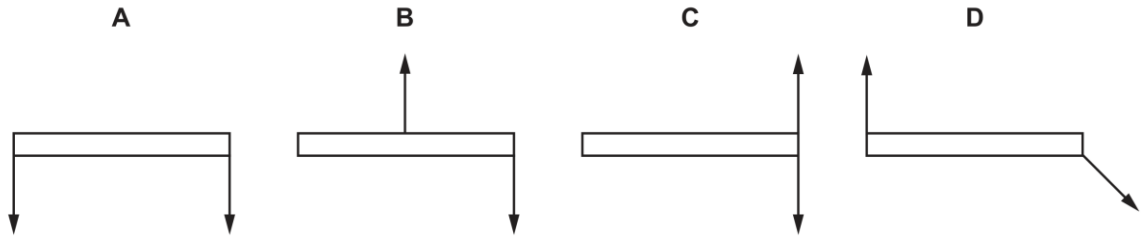
1 Two forces act on an object.

Which diagram represents a couple?

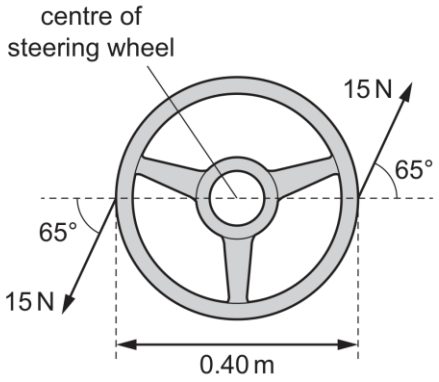


2 The diagrams all show a pair of equal forces acting on a metre rule.

Which diagram shows forces that provide a couple and zero resultant force?



3 The driver of a car applies two parallel forces to a steering wheel, as shown.



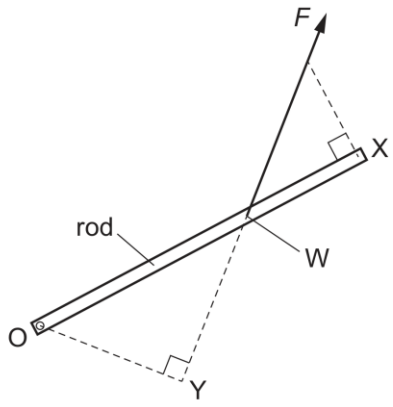
Each force has a magnitude of 15 N and acts in the direction shown. The steering wheel has a diameter of 0.40 m.

What is the torque exerted on the steering wheel?

A 1.3 N m **B** 2.5 N m **C** 2.7 N m **D** 5.4 N m

4 A rod is pivoted at point O.

A force *F* is applied to the rod at point W, as shown.



What is the moment of the force *F* about O?

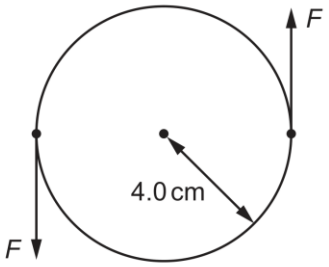
A *F* × distance OX

B *F* × distance OY

C *F* × distance WO

D *F* × distance WX

5 A minimum torque of 20 N m must be applied to the lid of a jar for it to open. The radius of the lid is 4.0 cm.



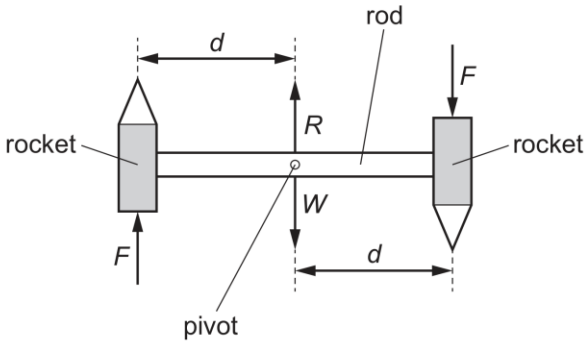
What is the minimum force *F* that must act on each side of the lid in order to open it?

A 2.5 N **B** 5.0 N **C** 250 N **D** 500 N

6 A type of firework is made by connecting two rockets, facing in opposite directions, to a rod, as shown.

The rod is attached to a frictionless pivot so that the firework can rotate in a vertical plane.

The firework has weight *W*. The pivot exerts a force *R* on the rod that is equal and opposite to *W*.



Each rocket exerts a force of magnitude *F* on the rod at a perpendicular distance *d* from the pivot. The forces exerted by the rockets are always in opposite directions.

Air resistance is negligible.

Which statement is correct?

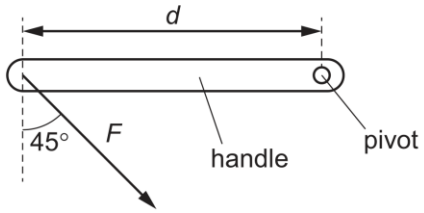
A The firework is in equilibrium because the resultant force acting on it is zero.

B The firework is in equilibrium because the resultant torque acting on it is zero.

C The firework is not in equilibrium because the resultant force acting on it is not zero.

D The firework is not in equilibrium because the resultant torque acting on it is not zero.

7 A force *F* is applied at an angle of 45° to a door handle at a distance *d* from the pivot of the handle, as shown.

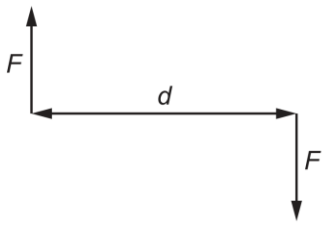


What is the moment of the force about the pivot?

A $\frac{Fd}{\sqrt{2}}$ **B** Fd **C** $Fd\sqrt{2}$ **D** $2Fd$

8 A couple consists of two forces, each of magnitude F, that act in opposite directions in the same plane.

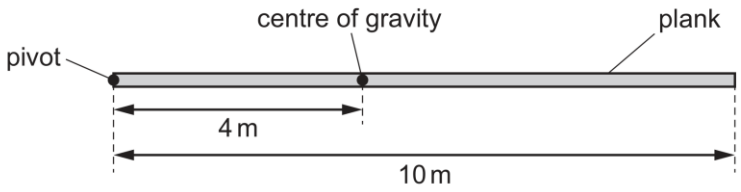
The perpendicular distance between the two forces is d.



What is the torque of the couple?

A $\frac{Fd}{2}$ **B** $\frac{F}{d}$ **C** Fd **D** $2Fd$

9 A horizontal wooden plank is pivoted at one end, as shown.



The plank has a mass of 100 kg and a length of 10 m. The centre of gravity of the plank is a distance of 4 m from the pivot.

What is the moment of the weight of the plank about the pivot?

A 4×10^2 N m **B** 5×10^2 N m **C** 4×10^3 N m **D** 5×10^3 N m

10 Two forces form a couple.

Which statement describes the two forces?

A They are in the same direction.

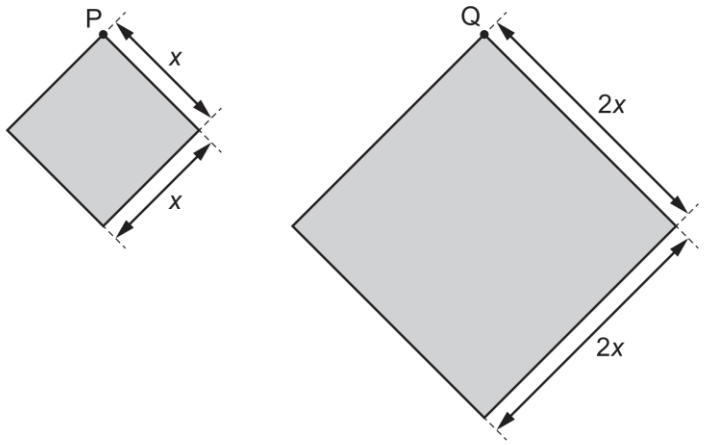
B They are perpendicular to each other.

C They have the same magnitude.

D They pass through the same point.

11 A square board, of side length x, hangs freely from a nail P, as shown.

The board has uniform thickness and is made from material of uniform density.



A second square board, of side length $2x$, is made of the same material and has the same thickness as the original board. This second board is then hung from a nail Q. Nails P and Q are at the same height.

What is the vertical distance between the positions of the centres of gravity of the two boards?

A 0 **B** $\frac{x}{\sqrt{2}}$ **C** x **D** $x\sqrt{2}$

12 What is **not** a necessary requirement of the forces in a couple?

A They act in opposite directions.

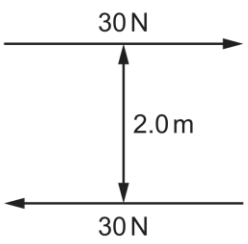
B They act along different lines.

C They have the same magnitude.

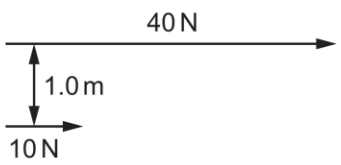
D They produce a resultant force.

13 Which pair of forces forms a couple with a torque of 30 N m?

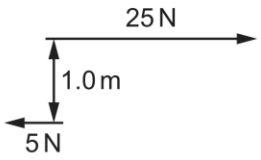
A



B



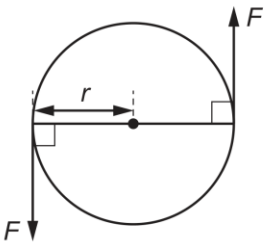
C



D



14 A disc of radius *r* is acted upon by two opposite forces, each of magnitude *F*. The forces form a couple, as shown.

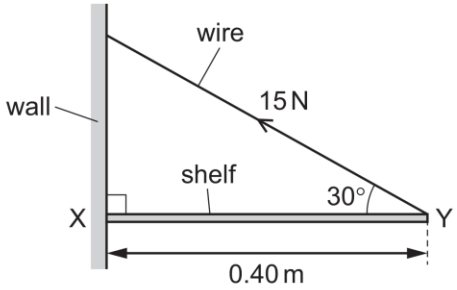


What is the torque of this couple?

A $\frac{1}{2}Fr$ **B** Fr **C** $2Fr$ **D** $4Fr$

15 A shelf XY is 0.40 m long and is attached to a wall at end X.

It is kept horizontal by a wire attached to Y and to the wall, as shown.

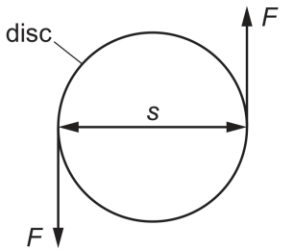


The tension force in the wire is 15 N at an angle of 30° to the horizontal.

What is the moment of this force about point X?

A 3.0 N m **B** 5.2 N m **C** 6.9 N m **D** 12 N m

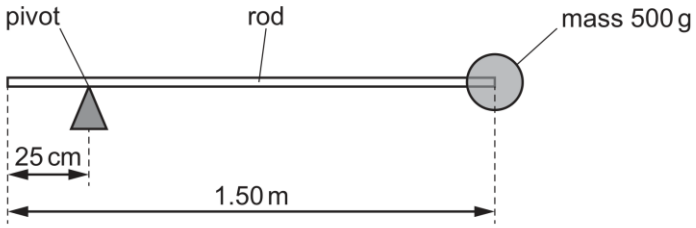
16 Two forces, each of magnitude *F*, act on a disc of diameter *s*, as shown.



What is the torque exerted on the disc?

A zero **B** $\frac{1}{2}Fs$ **C** Fs **D** $2Fs$

17 A mass of 500 g is attached at one end of a rod of length 1.50 m. The rod is pivoted at a distance of 25 cm from the other end. The rod is horizontal.



What is the moment about the pivot due to the mass?

A 0.63 N m **B** 1.2 N m **C** 6.1 N m **D** 7.4 N m

18 Which statement best describes a couple?

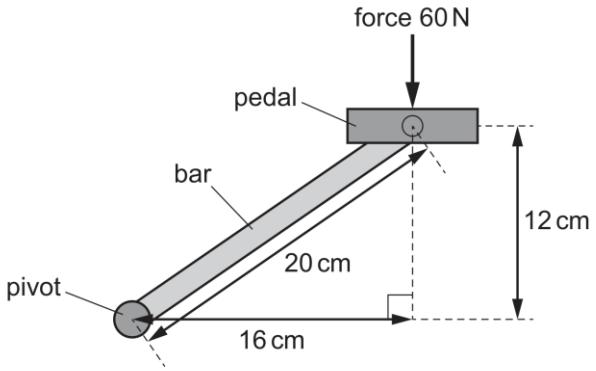
A a pair of forces of equal magnitude acting in opposite directions which produce rotational motion but not translational motion

B a pair of forces of equal magnitude acting in opposite directions which produce translational motion but not rotational motion

C a pair of forces of equal magnitude acting in the same direction which produce rotational motion but not translational motion

D a pair of forces of equal magnitude acting in the same direction which produce translational motion but not rotational motion

19 A bicycle pedal is connected to a pivot by a metal bar, as shown.



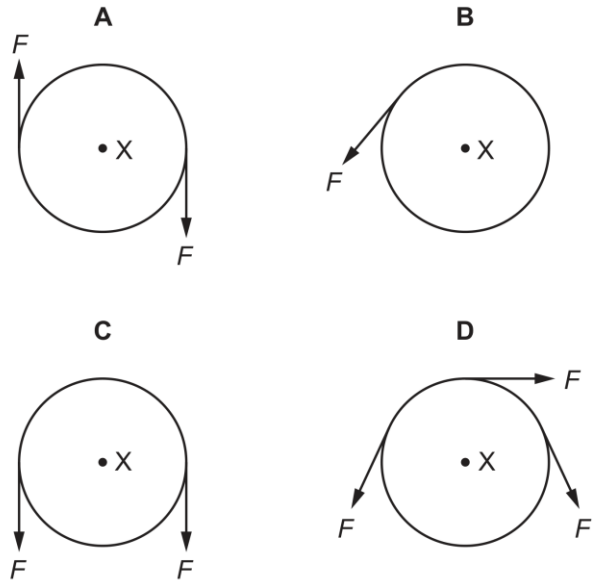
The force on the pedal is 60 N downwards.

What is the moment of this force about the pivot?

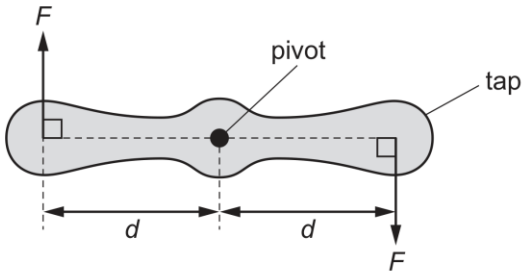
A 7.2 N m **B** 9.6 N m **C** 12 N m **D** 1200 N m

20 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 total moment of magnitude 2*Fr* about X?



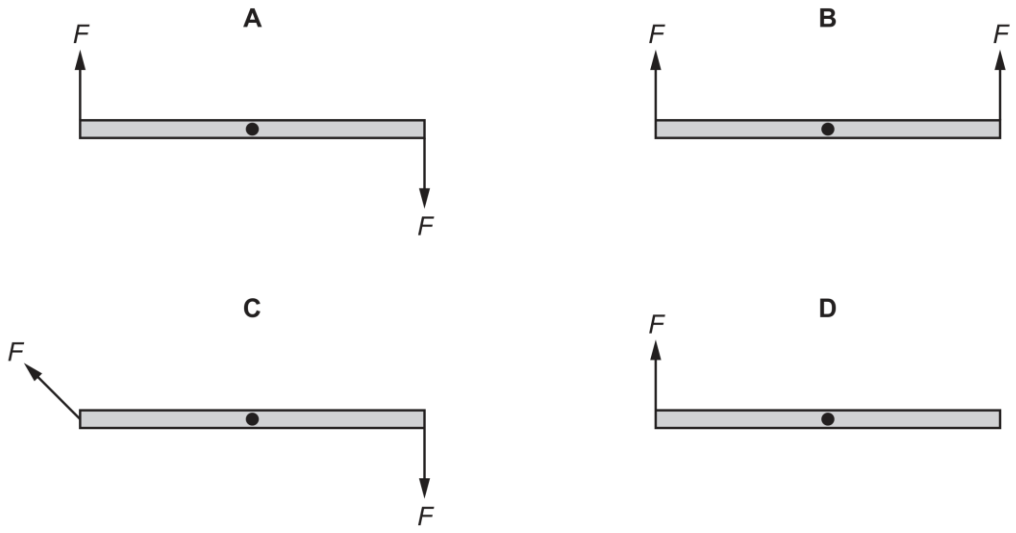
21 A couple is applied to a tap as shown.



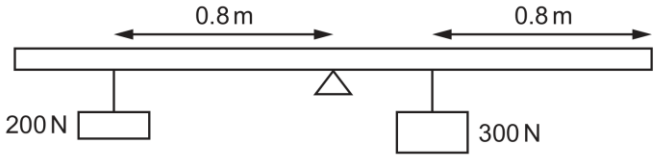
What is the torque of the couple?

A $\frac{Fd}{2}$ **B** Fd **C** $2Fd$ **D** $4Fd$

22 Which diagram shows a couple?



23 A rigid uniform bar of length 2.4 m is pivoted horizontally at its midpoint.



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

What is the torque and direction of this couple?

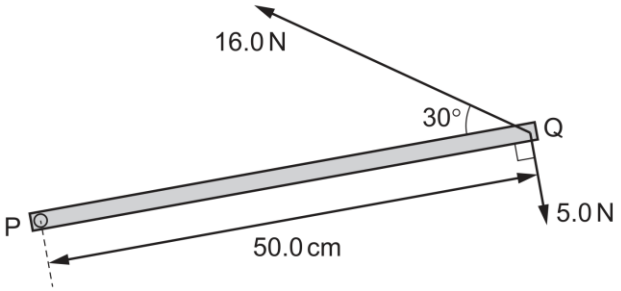
A 40 N m clockwise

B 40 N m anticlockwise

C 80 N m clockwise

D 80 N m anticlockwise

24 A horizontal metal bar PQ of length 50.0 cm is hinged at end P. The diagram shows the metal bar viewed from above.



Two forces of 16.0 N and 5.0 N are in the horizontal plane and act on end Q as shown in the diagram.

What is the total moment about P due to the two forces?

A 1.5 N m **B** 4.4 N m **C** 6.5 N m **D** 9.4 N m

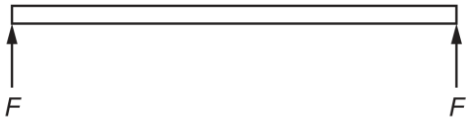
25 Two parallel forces, each of magnitude *F*, act on a rod of length 5*d*.

Which diagram shows the positions of the two forces that will produce the largest torque on the rod?

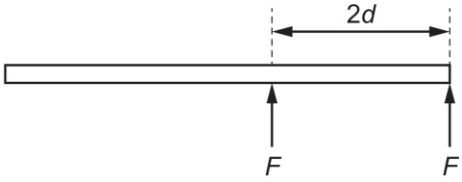
A



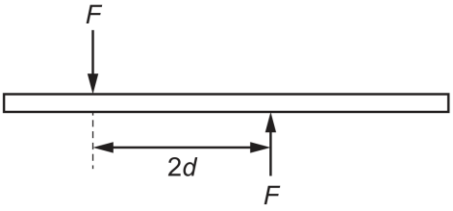
B



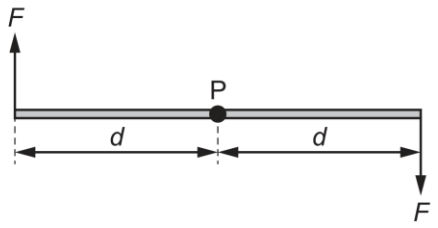
C



D



26 Two forces, each of magnitude F, act in opposite directions on a rod.



Each force acts on the rod at a distance d from the pivot P.

What is the torque of this couple about P?

A 0 **B** $F \times d$ **C** $2F \times d$ **D** $2F \times 2d$