

Q1.(a) Define the moment of a force about a point.

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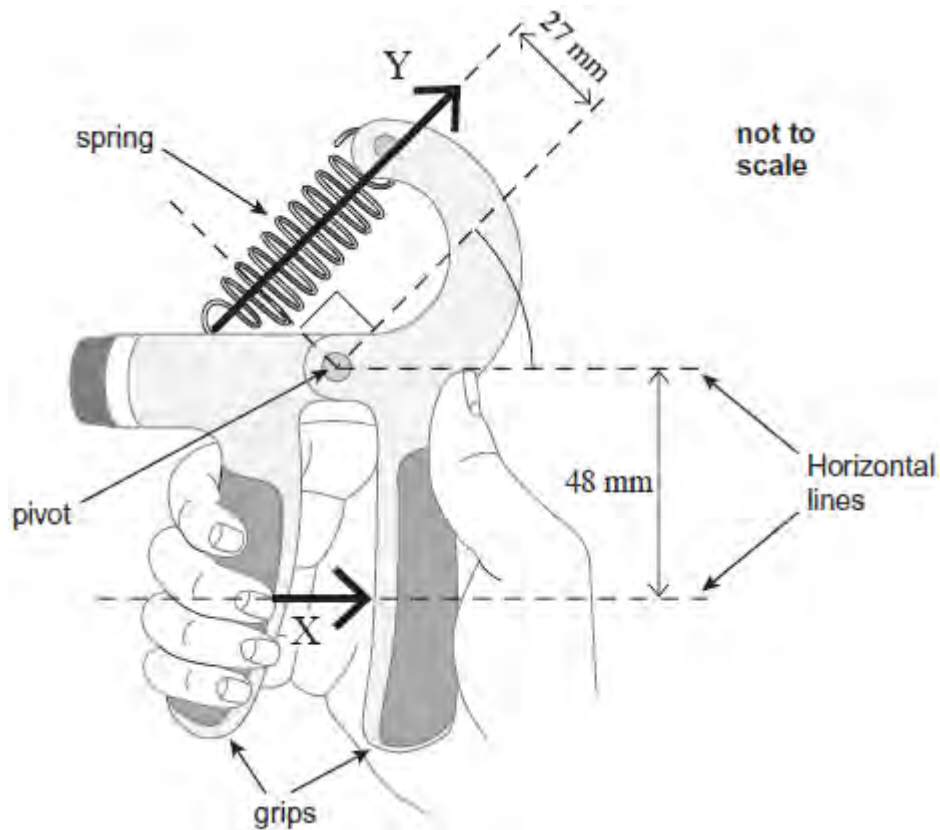
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(2)

(b) The diagram shows a gripper which is used for hand strengthening exercises.



The diagram shows the gripper being squeezed. In this situation, the gripper is in equilibrium. The force produced by the fingers is equivalent to the single force \mathbf{X} of magnitude 250 N acting in the direction shown above. A force, \mathbf{Y} , is exerted by the spring which obeys Hooke's law.

(i) Calculate the moment of force \mathbf{X} about the pivot. State an appropriate unit.

moment = unit

(2)

(ii) Calculate force **Y**.

force = N

(2)

(iii) The extension of the spring is 15 mm.

Calculate the spring constant k of the spring. Give your answer in N m^{-1} .

spring constant = N m^{-1}

(2)

(iv) Calculate the work done on the spring to squeeze it to the position shown in the diagram.

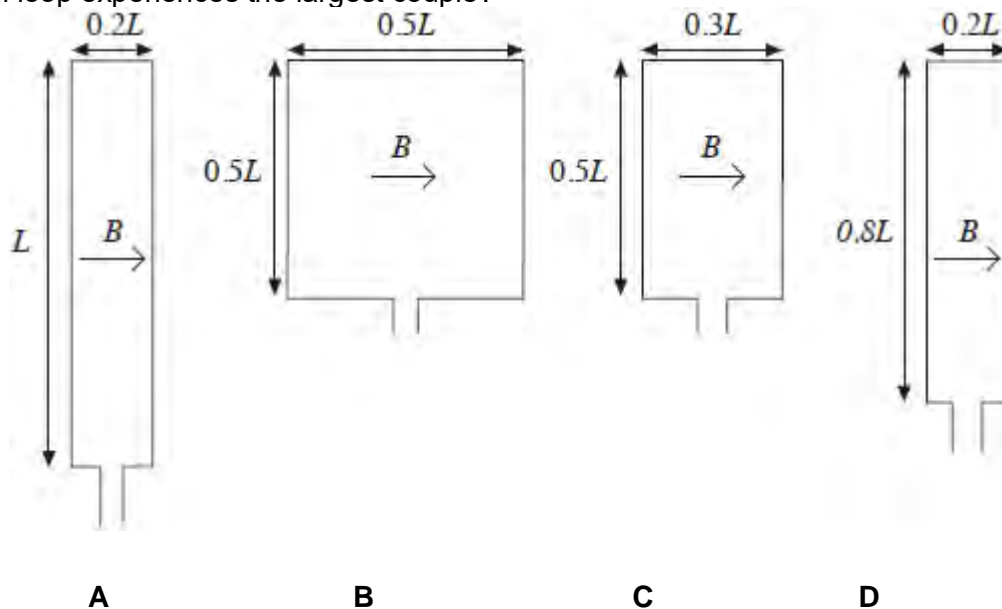
work done = J

(2)

Q2. Four rectangular loops of wire **A**, **B**, **C** and **D** are each placed in a uniform magnetic field of the same flux density B . The direction of the magnetic field is parallel to the plane of the loops as shown.

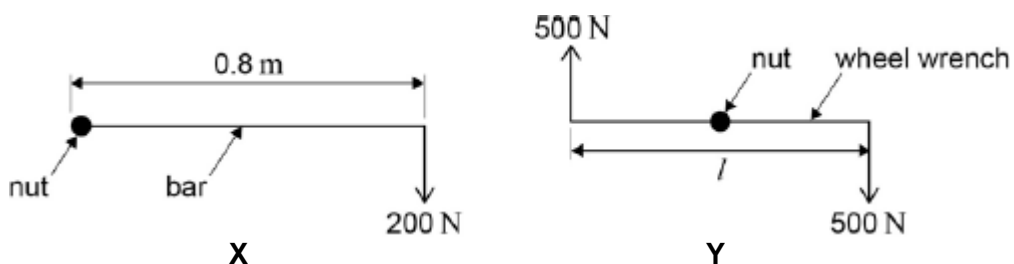
When a current of 1 A is passed through each of the loops, magnetic forces act on them. The lengths of the sides of the loops are as shown.

Which loop experiences the largest couple?



(Total 1 mark)

Q3. A car wheel nut can be loosened by applying a force of 200 N on the end of a bar of length 0.8 m as in **X**. A car mechanic is capable of applying forces of 500 N simultaneously in opposite directions on the ends of a wheel wrench as in **Y**.

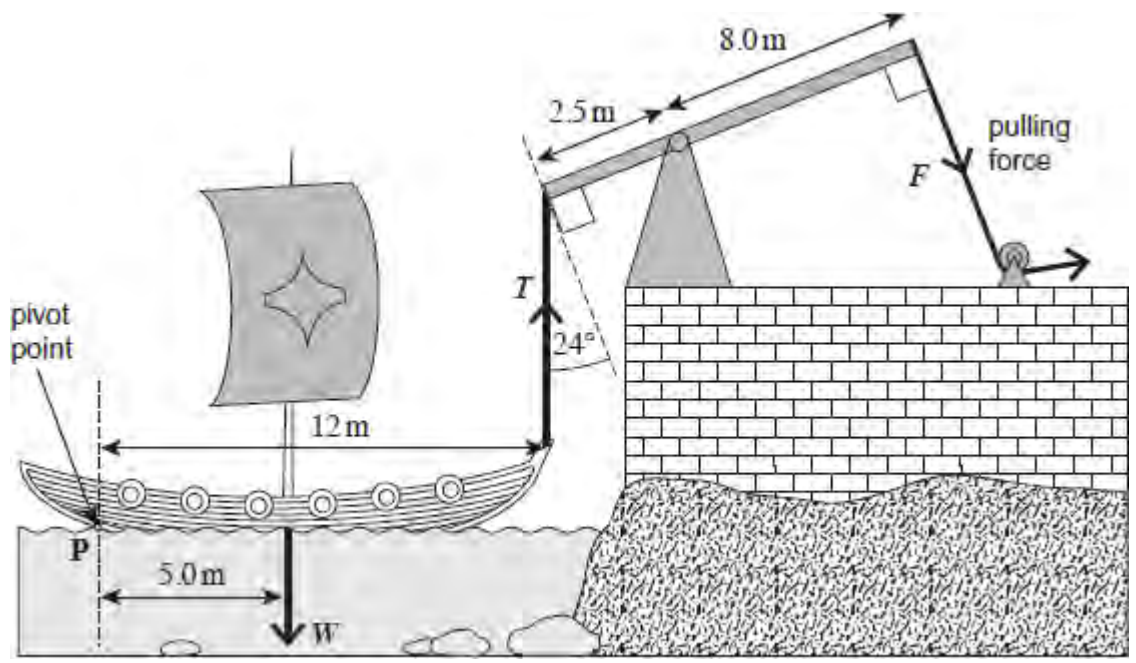


What is the minimum length l of the wrench which would be needed for him to loosen the nut?

- A 0.16 m
- B 0.32 m
- C 0.48 m
- D 0.64 m

(Total 1 mark)

Q4. It is said that Archimedes used huge levers to sink Roman ships invading the city of Syracuse. A possible system is shown in the following figure where a rope is hooked on to the front of the ship and the lever is pulled by several men.



(a) (i) Calculate the mass of the ship if its weight was 3.4×10^4 N.

mass kg

(1)

(ii) Calculate the moment of the ship's weight about point **P**. State an appropriate unit for your answer.

moment unit

(2)

- (iii) Calculate the minimum vertical force, T , required to start to raise the front of the ship.

Assume the ship pivots about point P .

minimum vertical force N

(2)

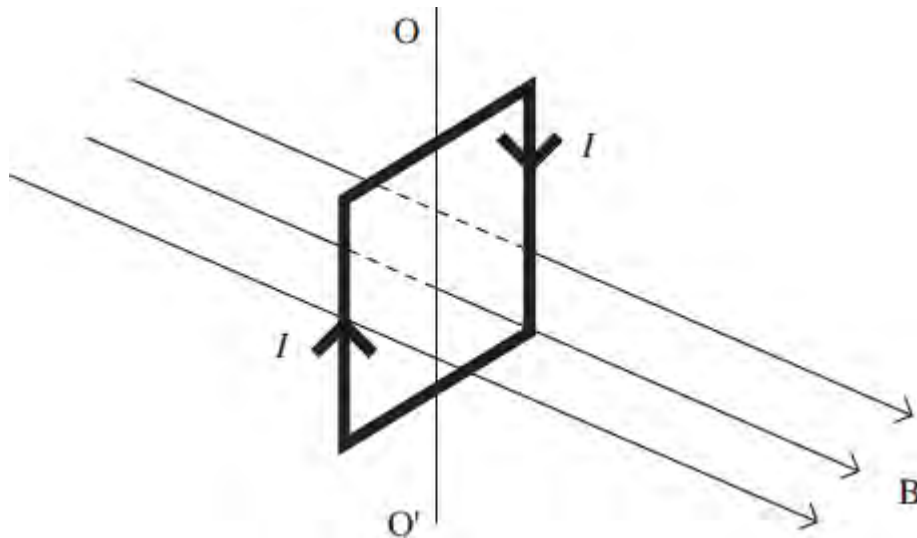
- (iv) Calculate the minimum force, F , that must be exerted to start to raise the front of the ship.

force N

(3)

(Total 8 marks)

Q5. The diagram shows a vertical square coil whose plane is at right angles to a horizontal uniform magnetic field B . A current, I , is passed through the coil, which is free to rotate about a vertical axis OO' .



Which one of the following statements is correct?

- A The forces on the two vertical sides of the coil are equal and opposite.
- B A couple acts on the coil.
- C No forces act on the horizontal sides of the coil.
- D If the coil is turned through a small angle about OO' and released, it will remain in position.

(Total 1 mark)

Q6.(a) State the principle of moments.

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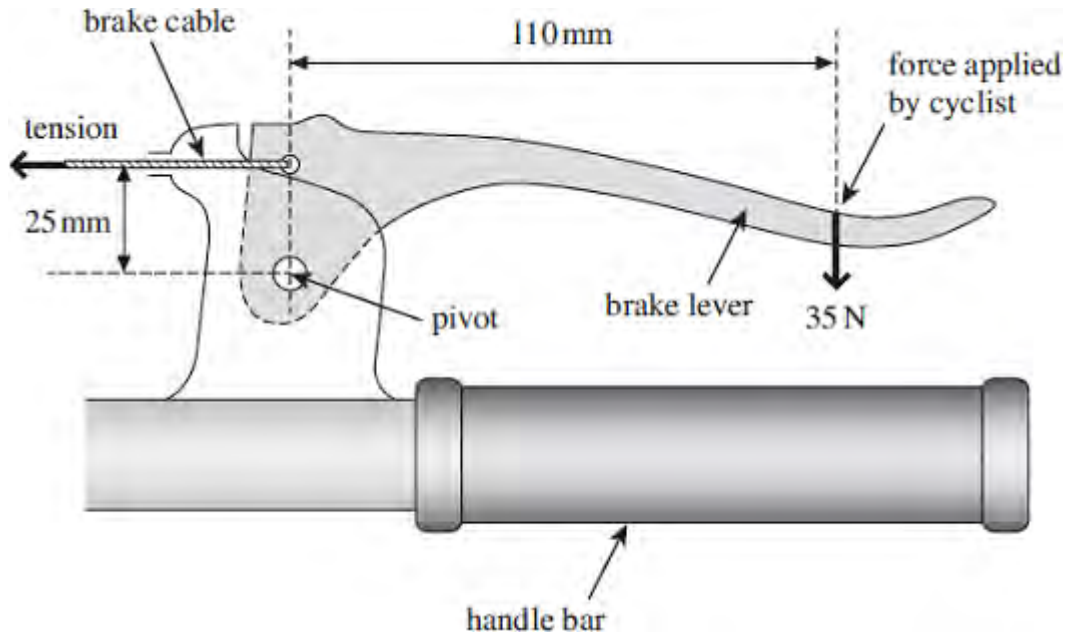
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(3)

(b) The diagram below shows a bicycle brake lever that has been pulled with a 35 N force to apply the brake.



- (i) Calculate the moment of the force applied by the cyclist about the pivot. State an appropriate unit.

moment =unit

(3)

- (ii) Calculate the tension in the brake cable. Assume the weight of the lever is negligible.

tension = N

(3)

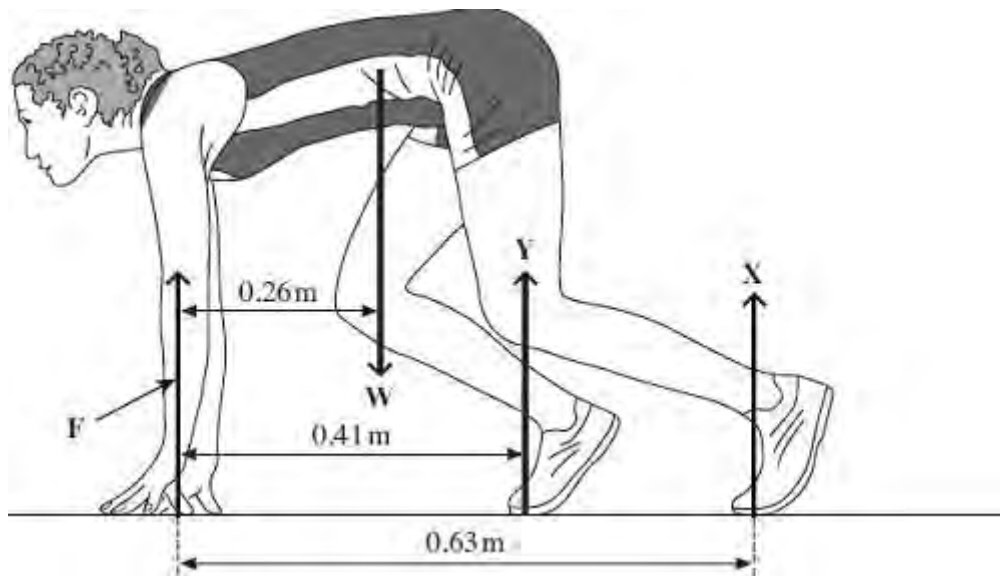
- (c) In order to maintain a constant velocity of 15 ms^{-1} downhill, the cyclist applies the brake. The power developed by the braking force is 2.8 kW.

Calculate the total average frictional force between the brake blocks and the wheel rim.

frictional force = N

(2)
(Total 11 marks)

Q7. A sprinter is shown before a race, stationary in the 'set' position, as shown in the figure below. Force **F** is the resultant force on the sprinter's finger tips. The reaction force, **Y**, on her forward foot is 180 N and her weight, **W**, is 520 N. **X** is the vertical reaction force on her back foot.



- (a) (i) Calculate the moment of the sprinter's weight, **W**, about her finger tips. Give an appropriate unit.

answer = unit

(2)

- (ii) By taking moments about her finger tips, calculate the force on her back foot, marked **X**.

answer =N (3)

(iii) Calculate the force **F**.

answer =N (1)

(b) The sprinter starts running and reaches a horizontal velocity of 9.3 ms^{-1} in a distance of 35 m.

(i) Calculate her average acceleration over this distance.

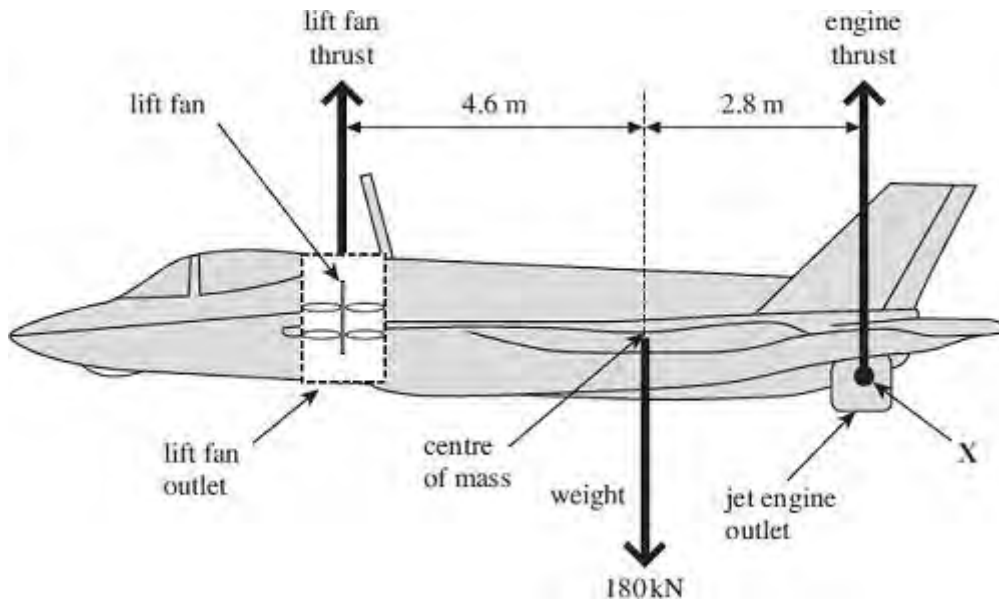
answer = m s^{-2} (2)

(ii) Calculate the resultant force necessary to produce this acceleration.

answer =N (2)
(Total 10 marks)

Q8. The figure below shows an aircraft designed to take off and land vertically and also to hover without horizontal movement. In order to achieve this, upward lift is produced by directing the jet engine outlet downwards. The engine also drives a vertical lift fan near the

front of the aircraft. The weight of the aircraft is 180 kN. The distance between the lift fan and the centre of mass is 4.6 m and the distance between the jet engine outlet and the centre of mass is 2.8 m.



- (a) (i) Calculate the moment caused by the weight of the aircraft about the point X.

answer = Nm

(2)

- (ii) By taking moments about X, calculate the lift fan thrust if the aircraft is to remain horizontal when hovering.

answer = N

(3)

- (iii) Calculate the engine thrust in the figure above.

answer = N

(1)

(b) Having taken off vertically, the jet engine outlet is turned so that the engine thrust acts horizontally. The aircraft accelerates horizontally to a maximum velocity. The forward thrust produced by the jet is 155 kN. The weight of the aircraft is 180 kN.

(i) When the resultant horizontal force is 155 kN, calculate the horizontal acceleration of the aircraft.

answer = ms^{-2}

(2)

(ii) State and explain **one** characteristic of the aircraft that limits its maximum horizontal velocity.

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(2)

(iii) On the axes below, sketch the velocity-time graph for the horizontal motion of the aircraft as it accelerates from zero to its maximum horizontal velocity.



(2)

(c) State how a velocity-time graph could be used to find the maximum acceleration.

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(1)

(Total 13 marks)