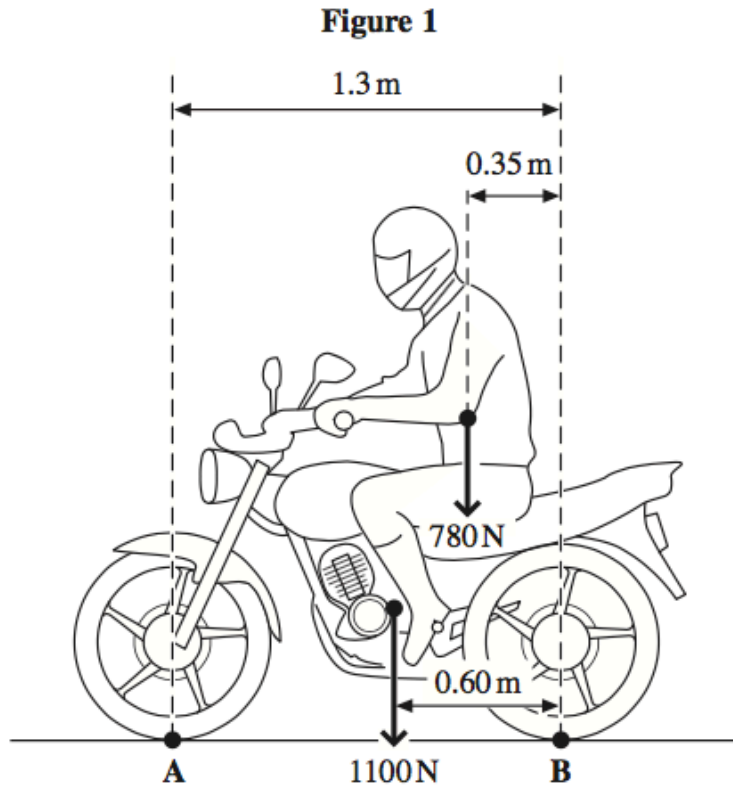


1)

Figure 1 shows a motorcycle and rider. The motorcycle is in contact with the road at **A** and **B**.



The motorcycle has a weight of 1100 N and the rider's weight is 780 N.

(a) State the Principle of Moments.

.....

.....

.....

(2 marks)

(b) Calculate the moment of the rider's weight about **B**. Give an appropriate unit.

answer =

(2 marks)

- (c) By taking the moments about **B**, calculate the vertical force that the road exerts on the front tyre at **A**. State your answer to an appropriate number of significant figures.

answer = N
(4 marks)

- (d) Calculate the vertical force that the road exerts on the rear tyre at **B**.

answer = N
(1 mark)

- (e) The maximum power of the motorcycle is 7.5 kW and it has a maximum speed of 26 m s^{-1} , when travelling on a level road.

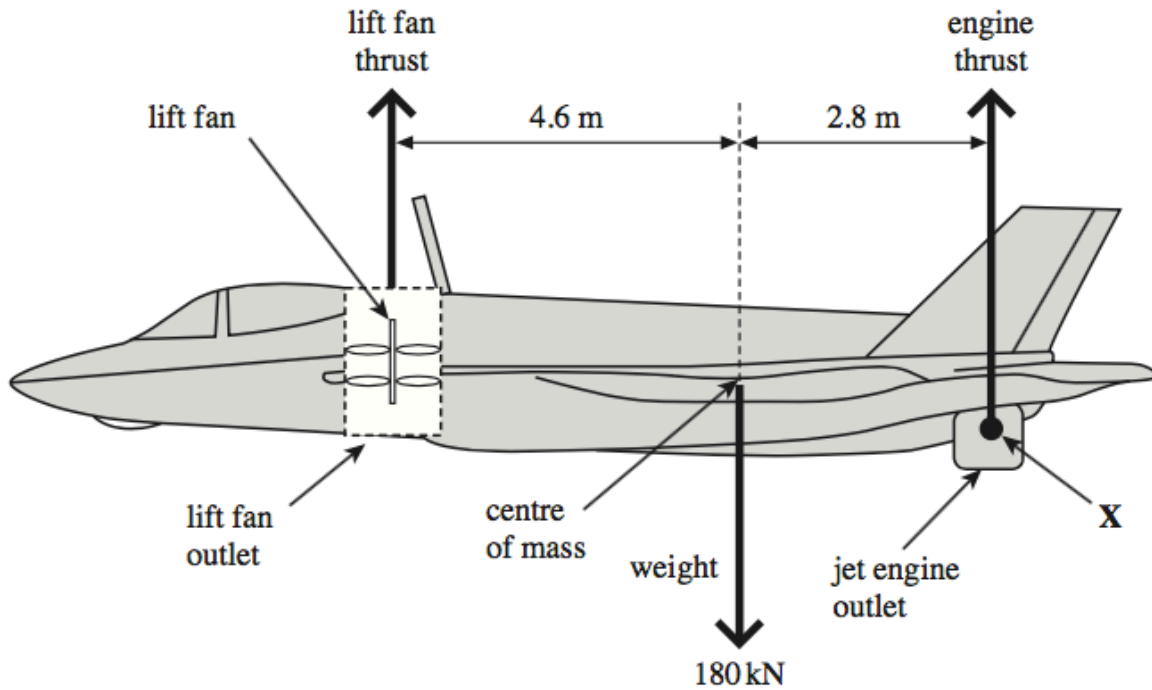
Calculate the total horizontal resistive force for this speed.

answer = N
(2 marks)

2)

Figure 3 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.

Figure 3



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

answer = N m
(2 marks)

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

answer = N
(3 marks)

(a) (iii) Calculate the engine thrust in **Figure 3**.

answer = N
(1 mark)

(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.

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

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

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

.....
.....
.....
.....

(2 marks)

(b) (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.



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

.....
(1 mark)

3)

(a) State the principle of moments.

.....

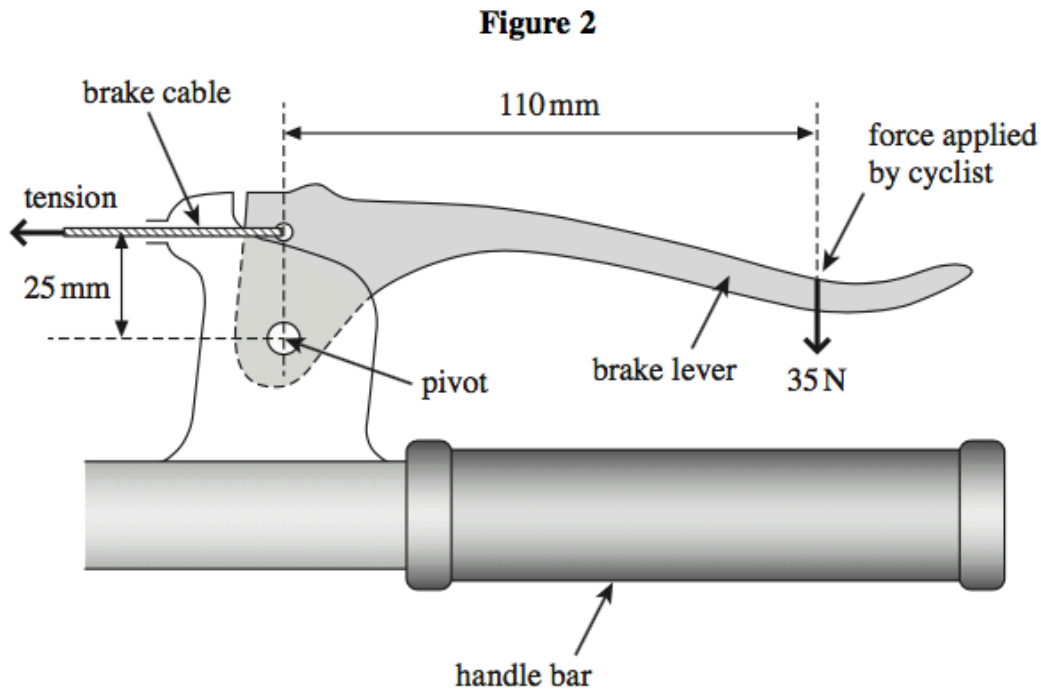
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(3 marks)

(b) **Figure 2** shows a bicycle brake lever that has been pulled with a 35 N force to apply the brake.



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

moment = unit
(3 marks)

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

tension = N
(3 marks)

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

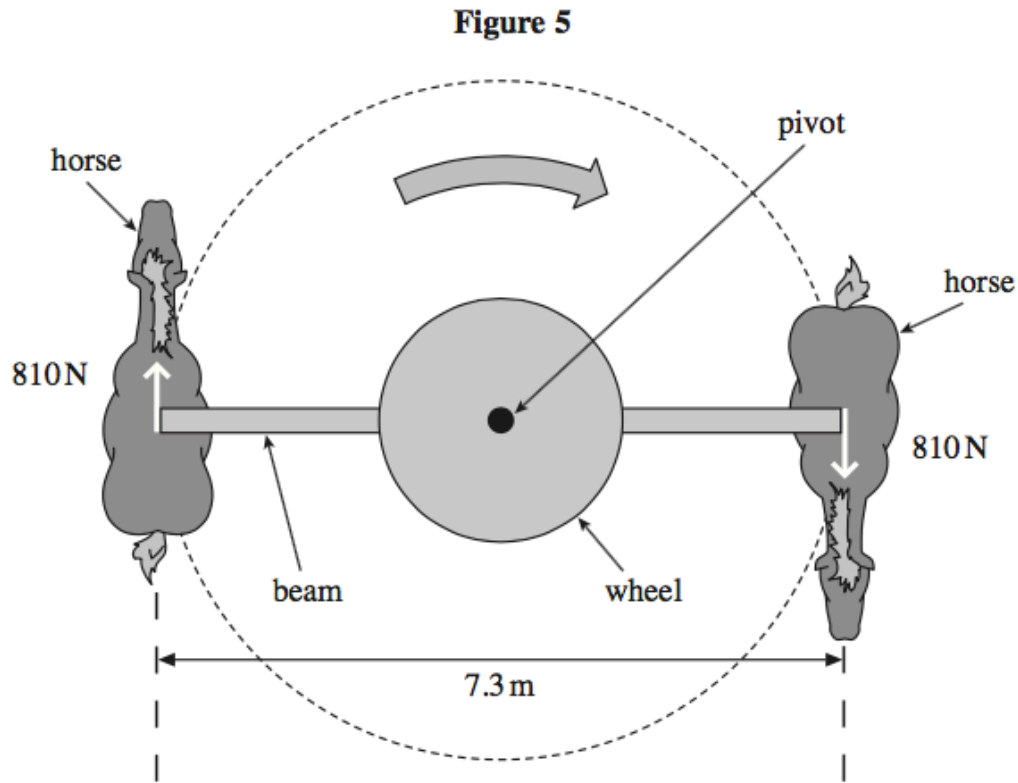
Calculate the total average frictional force between the brake blocks and the wheel rim.

frictional force = N
(2 marks)

4)

Horses were once used to power machinery in factories, mines and mills.

Figure 5 shows two horses attached to a beam which turns a wheel. This wheel drives machinery.



(a) Each horse exerts a force of 810 N and the length of the beam is 7.3 m.

(a) (i) Define the moment of a couple.

.....

.....

.....

(2 marks)

(a) (ii) Calculate the moment of the couple exerted by the horses, stating an appropriate unit.

answer =
(2 marks)

- (b) The horses move at a constant speed of 0.91 ms^{-1} . Calculate the combined power output of the two horses. Give your answer to an appropriate number of significant figures.

answer = W
(3 marks)

- (c) During the Industrial Revolution in the 19th Century, James Watt became well known for developing and improving steam engines to replace horses. He defined the unit of power called '*horsepower*' by studying a system similar to the one shown in **Figure 5**.

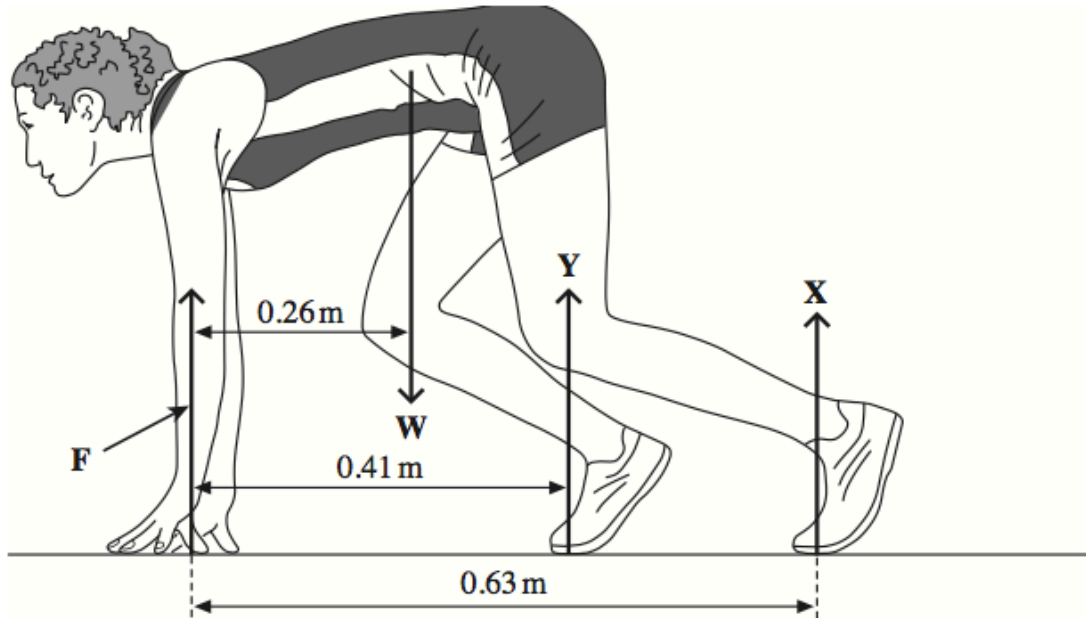
Suggest why Watt decided to use *horsepower* as a unit of power.

.....
.....
.....
(1 mark)

5)

A sprinter is shown before a race, stationary in the ‘set’ position, as shown in **Figure 4**. 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.

Figure 4



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

answer = unit
(2 marks)

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

answer =N
(3 marks)

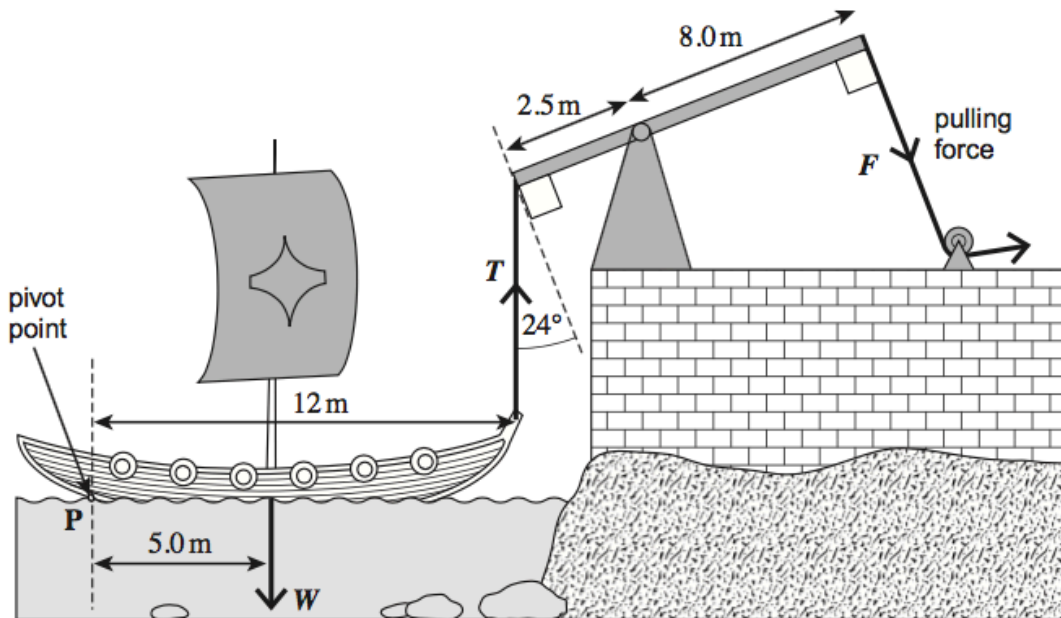
(a) (iii) Calculate the force **F**.

answer =N
(1 mark)

6)

It is said that Archimedes used huge levers to sink Roman ships invading the city of Syracuse. A possible system is shown in **Figure 3** where a rope is hooked on to the front of the ship and the lever is pulled by several men.

Figure 3



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

[1 mark]

mass kg

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

[2 marks]

moment unit

- (a) (iii) Calculate the minimum vertical force, T , required to start to raise the front of the ship. Assume the ship pivots about point P .

[2 marks]

minimum vertical force N

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

[3 marks]

force N

7)

7)

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

[2 marks]

.....

.....

.....

.....

(b) Figure 2 shows a gripper which is used for hand strengthening exercises.

Figure 2

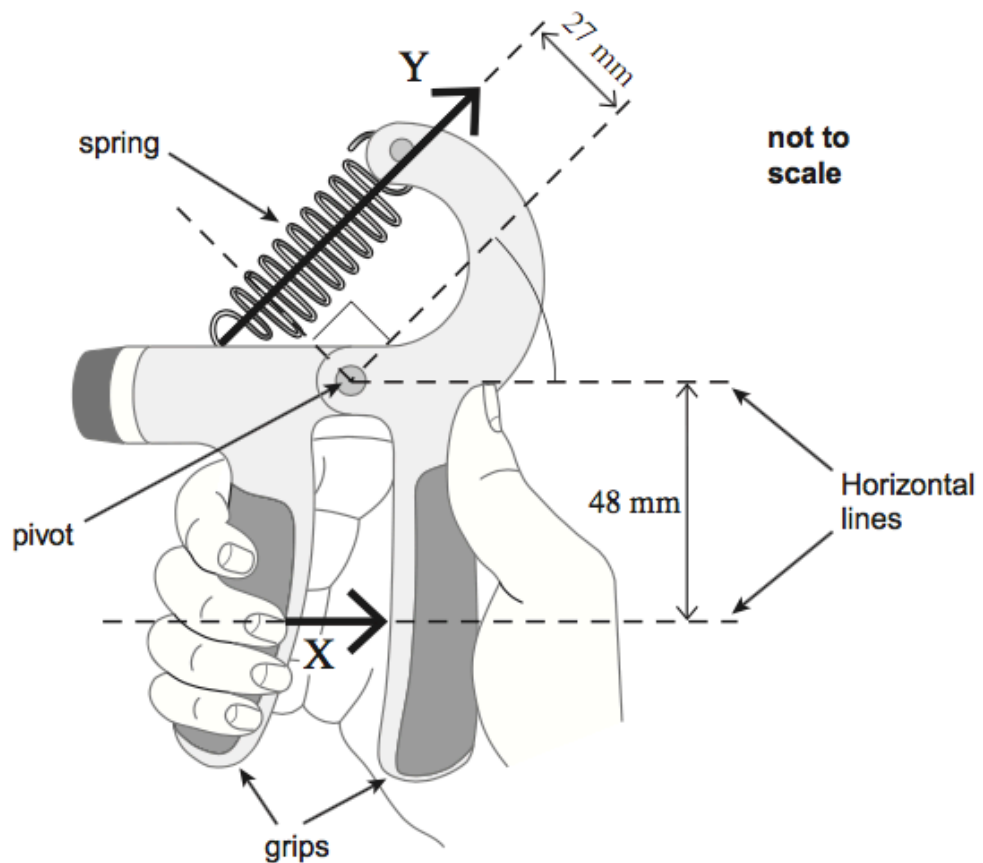


Figure 2 shows the gripper being squeezed. In this situation, the gripper is in equilibrium. The force produced by the fingers is equivalent to the single force X of magnitude 250 N acting in the direction shown in Figure 2. A force, Y , is exerted by the spring which obeys Hooke's law.

(b) (i) Calculate the moment of force **X** about the pivot. State an appropriate unit. **[2 marks]**

moment = unit

(b) (ii) Calculate force **Y**. **[2 marks]**

force = N

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

Calculate the spring constant k of the spring. Give your answer in N m^{-1} . **[2 marks]**

spring constant = N m^{-1}

(b) (iv) Calculate the work done on the spring to squeeze it to the position shown in **Figure 2**. **[2 marks]**

work done = J