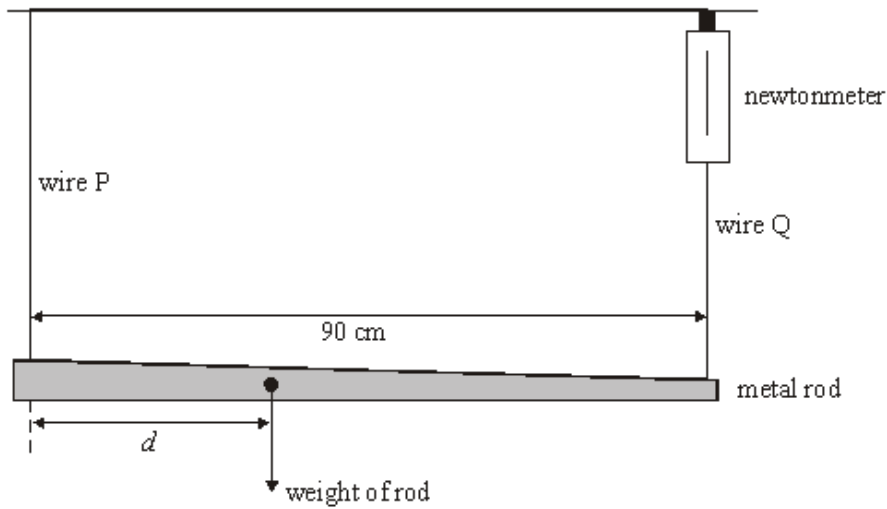


**Q1.** The figure below shows an apparatus used to locate the centre of gravity of a non-uniform metal rod.



The rod is supported horizontally by two wires, P and Q and is in equilibrium.

(a) State **two** conditions that must be satisfied for the rod to be in equilibrium.

.....

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.....

.....

(2)

(b) Wire Q is attached to a newtonmeter so that the force the wire exerts on the rod can be measured. The reading on the newtonmeter is 2.0 N and the weight of the rod is 5.0 N. Calculate

(i) the force that wire P exerts on the rod,

.....

(ii) the distance  $d$ .

.....

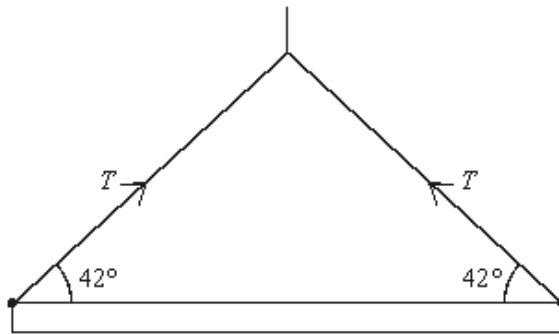
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(3)

(Total 5 marks)

**Q2.** The figure below shows a uniform steel girder being held horizontally by a crane. Two cables are attached to the ends of the girder and the tension in each of these cables is  $T$ .



(a) If the tension,  $T$ , in each cable is 850 N, calculate

(i) the horizontal component of the tension in each cable,

.....  
 .....

(ii) the vertical component of the tension in each cable,

.....  
 .....

(iii) the weight of the girder.

.....  
 .....

(4)

(b) On the figure draw an arrow to show the line of action of the weight of the girder.

(1)

(Total 5 marks)

**Q3.** (a) (i) State **two** vector quantities.

vector quantity 1 .....

vector quantity 2 .....

(ii) State **two** scalar quantities.

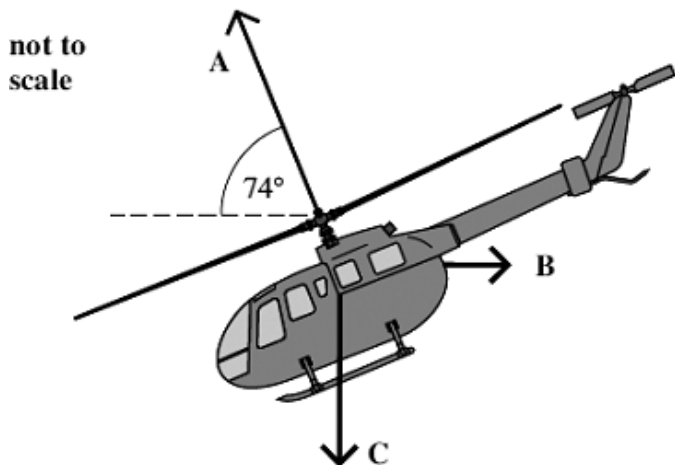
scalar quantity 1 .....

scalar quantity 2 .....

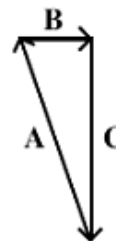
(2)

- (b) The helicopter shown in **Figure 1a** is moving horizontally through still air. The lift force from the helicopter's blades is labelled **A**.

**Figure 1a**



**Figure 1b**



- (i) Name the two forces **B** and **C** that also act on the helicopter.

**B** .....

**C** .....

(2)

- (ii) The force vectors are also shown arranged as a triangle in **Figure 1b**.

State and explain how **Figure 1b** shows that the helicopter is moving at a constant velocity.

.....  
 .....  
 .....  
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(2)

- (c) The lift force, **A**, is 9.5 kN and acts at an angle of 74° to the horizontal.

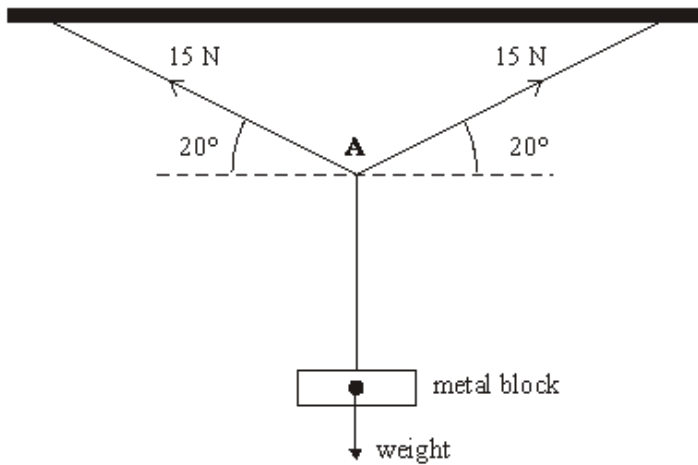
Calculate the weight of the helicopter. Give your answer to an appropriate number of significant figures.

answer = ..... N

(3)

(Total 9 marks)

**Q4.** The figure below shows a stationary metal block hanging from the middle of a stretched wire which is suspended from a horizontal beam. The tension in each half of the wire is 15 N.



(a) Calculate for the wire at A,

(i) the resultant horizontal component of the tension forces,

.....  
 .....

(ii) the resultant vertical component of the tension forces.

.....  
 .....

(3)

(b) (i) State the weight of the metal block.

.....

(ii) Explain how you arrived at your answer, with reference to an appropriate law of motion.

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

(3)

(Total 6 marks)

**Q5.** (a) (i) State the difference between a scalar quantity and a vector quantity.

.....  
 .....

(1)

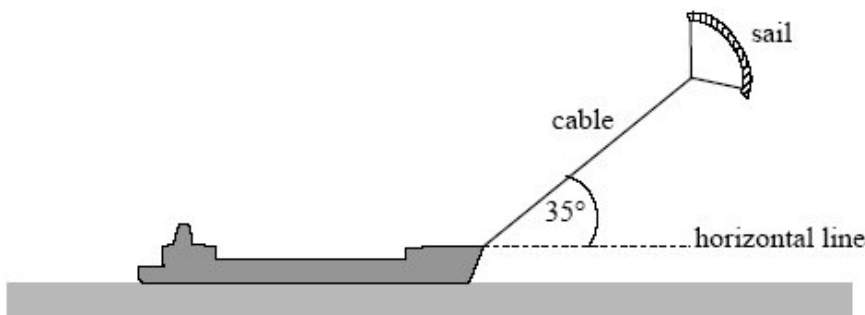
(ii) State **two** examples of a scalar quantity and **two** examples of a vector quantity.

scalar quantities .....

vector quantities .....

(3)

(b) The diagram below shows a ship fitted with a sail attached to a cable. The force of the wind on the sail assists the driving force of the ship's propellers.



The cable exerts a steady force of 2.8 kN on the ship at an angle of 35° above a horizontal line.

(i) Calculate the horizontal and vertical components of this force.

horizontal component of force ..... kN

vertical component of force ..... kN

(2)

(ii) The ship is moving at a constant velocity of 8.3 m s<sup>-1</sup> and the horizontal component of the force of the cable on the ship acts in the direction in which the ship is moving. Calculate the power provided by the wind to this ship, stating an appropriate unit.

Answer .....

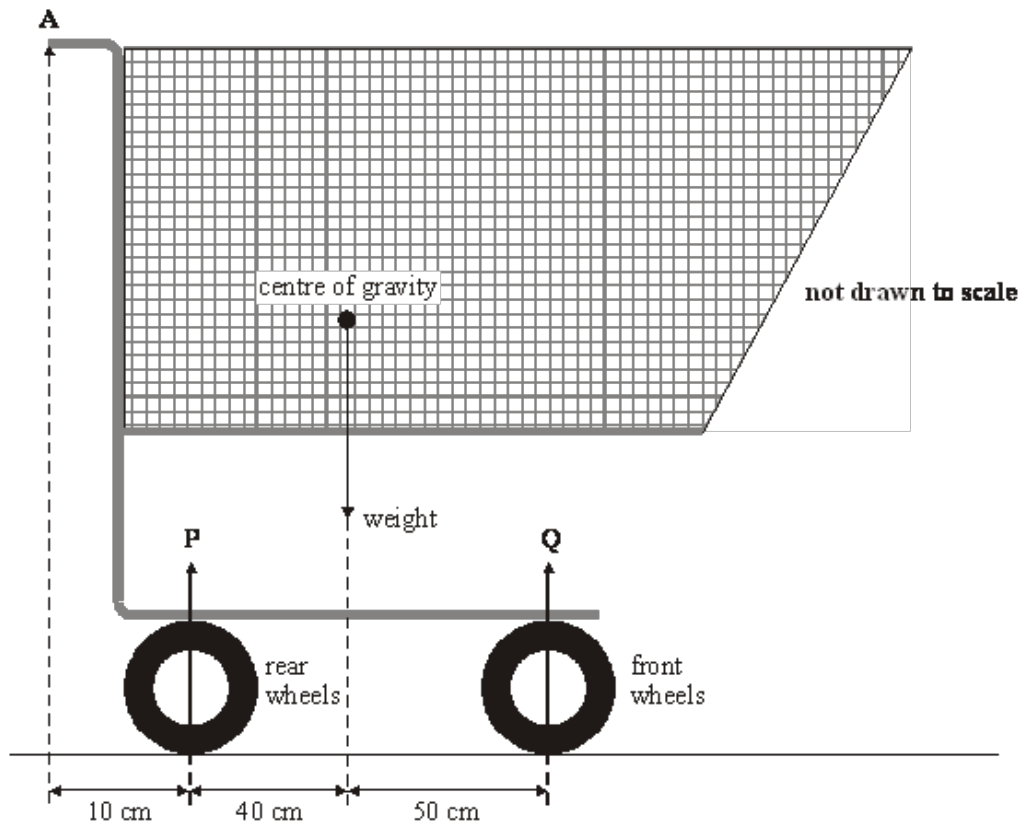
(3)

- (c) The cable has a diameter of 0.014 m. Calculate the tensile stress in the cable when it exerts a force of 2.8 kN on the ship, stating an appropriate unit. Assume the weight of the cable is negligible.

Answer .....

(5)  
(Total 14 marks)

**Q6.** The figure below shows a supermarket trolley.



The weight of the trolley and its contents is 160 N.

- (a) Explain what is meant by centre of gravity.

.....  
.....

(2)

(b) **P** and **Q** are the resultant forces that the ground exerts on the rear wheels and front wheels respectively. Calculate the magnitude of

(i) force **P**,

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

(ii) force **Q**.

.....  
.....

(3)

(c) Calculate the minimum force that needs to be applied vertically at **A** to lift the front wheels off the ground.

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

(2)

(d) State and explain, without calculation, how the minimum force that needs to be applied vertically at **A** to lift the rear wheels off the ground compares to the force you calculated in part (c).

You may be awarded marks for the quality of written communication in your answer.

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.....  
.....

(3)

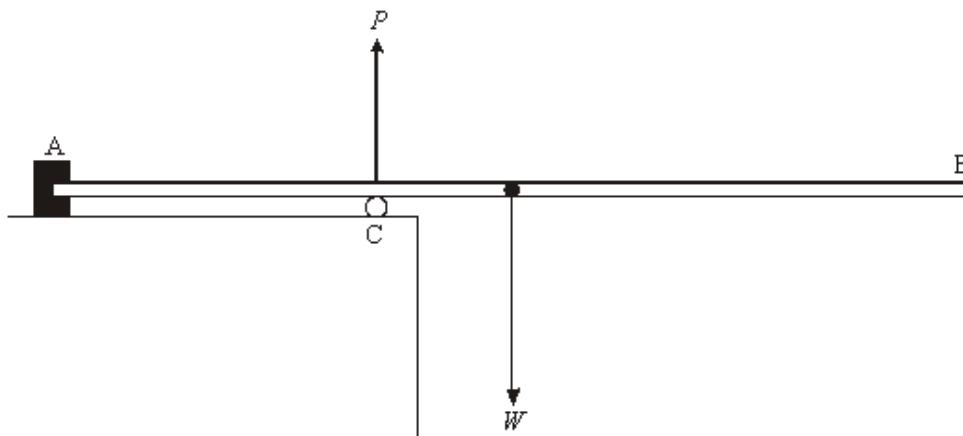
(Total 10 marks)

**Q7.** (a) Define the moment of a force.

.....  
.....

(2)

- (b) The diagram shows a uniform diving board of weight,  $W$ , that is fixed at A. The diving board is supported by a cylinder at C, that exerts an upward force,  $P$ , on the board.



- (i) By considering moments about A, explain why the force  $P$  must be greater than the weight of the board,  $W$ .

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.....  
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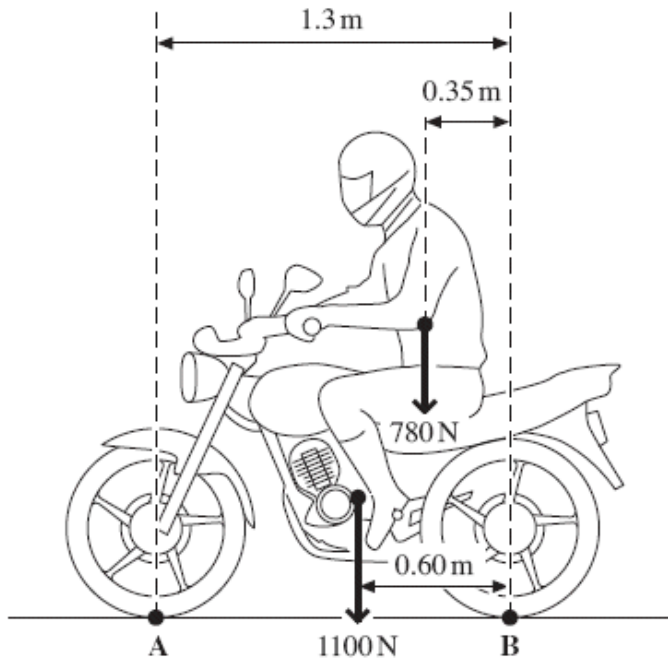
- (ii) State and explain what would be the effect on the force  $P$  of a girl walking along the board from A to B.

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

(4)  
(Total 6 marks)



**Q8.** The figure below 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)

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

answer = .....

(2)

- (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)

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

answer = ..... N

(1)

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

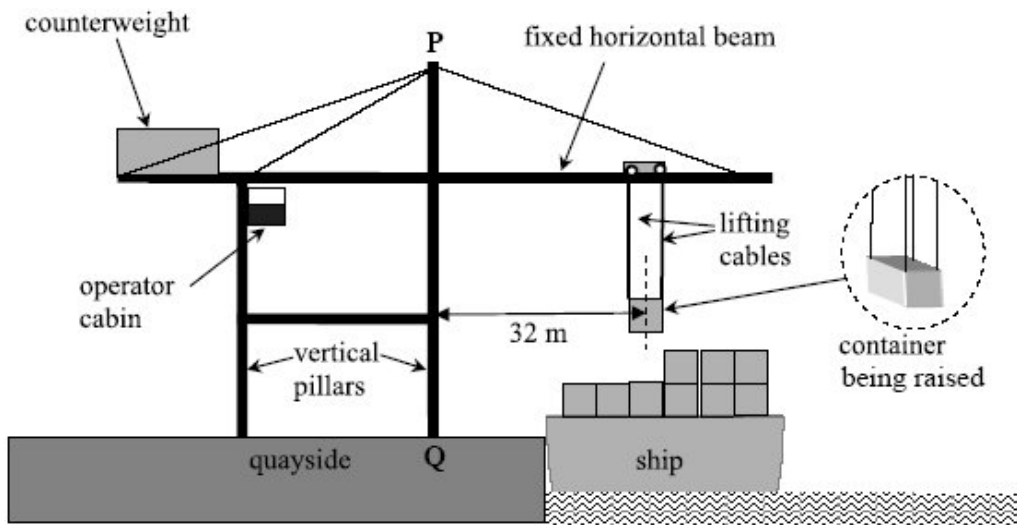
Calculate the total horizontal resistive force for this speed.

answer = ..... N

(2)

(Total 11 marks)

**Q9.** The diagram below shows a dockside crane that is used to lift a container of mass 22000 kg from a cargo ship onto the quayside. The container is lifted by four identical 'lifting' cables attached to the top corners of the container.



- (a) When the container is being raised, its centre of mass is at a horizontal distance 32 m from the nearest vertical pillar **PQ** of the crane's supporting frame.
- (i) Assume the tension in each of the four lifting cables is the same. Calculate the tension in each cable when the container is lifted at constant velocity.

answer ..... N

(2)

- (ii) Calculate the moment of the container's weight about the point **Q** on the quayside, stating an appropriate unit.

answer .....

(3)

- (iii) Describe and explain one feature of the crane that prevents it from toppling over when it is lifting a container.

.....

.....

.....

.....

.....

(2)

- (b) Each cable has an area of cross-section of  $3.8 \times 10^{-4} \text{ m}^2$ .
  - (i) Calculate the tensile stress in each cable, stating an appropriate unit.

answer .....

(3)

- (ii) Just before the container shown in the diagram above was raised from the ship, the length of each lifting cable was 25 m. Show that each cable extended by 17 mm when the container was raised from the ship.

Young modulus of steel =  $2.1 \times 10^{11} \text{ Pa}$

(2)

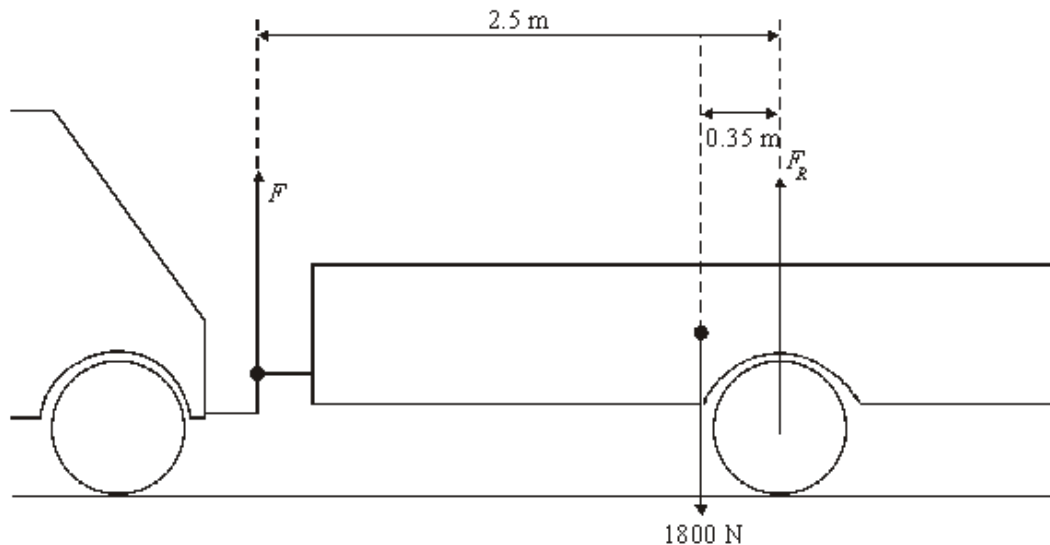
(Total 12 marks)

- Q10.** (a) Define the moment of a force about a point.

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

(2)

- (b) The diagram shows a trailer attached to the towbar of a stationary car. The weight of the trailer is 1800 N and is shown acting through its *centre of gravity*.  $F$  is the force exerted by the towbar on the trailer.  $F_R$  is the **total** normal reaction force experienced by the trailer. When stationary all forces acting on the trailer are vertical.



- (i) Explain what is meant by centre of gravity.

.....  
 .....

- (ii) Calculate the force,  $F$ , exerted by the towbar on the trailer.

.....  
 .....

(3)

- (iii) Calculate  $F_R$ .

.....  
 .....

(2)

- (c) The car starts to move forwards. State and explain what happens to the magnitude and direction of force,  $F$ .

You may be awarded marks for the quality of written communication in your answer.

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(3)  
(Total 10 marks)