LONDON SCIENCE COLLEGE

Name:

Date:

MOMENTS
TEST 2

AS-Level

Mark

Grade

PHYSICS

For this paper you must have:

- Ruler
- Pencil and Rubber
- Scientific calculator, which you are expected to use when appropriate

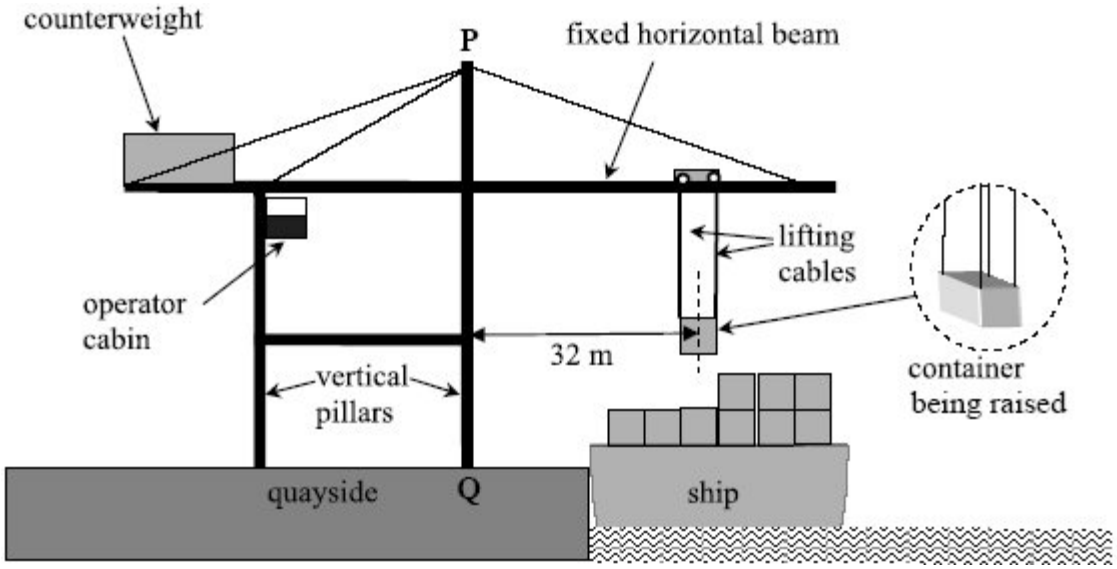
Instructions

- Answer all questions
- Answer questions in the space provided
- All working must be shown

Information

- The marks for the questions are shown in brackets

1 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 3.8×10^{-4} m^2.

(i) Calculate the tensile stress in each cable, stating an appropriate unit.

answer _____

(3)

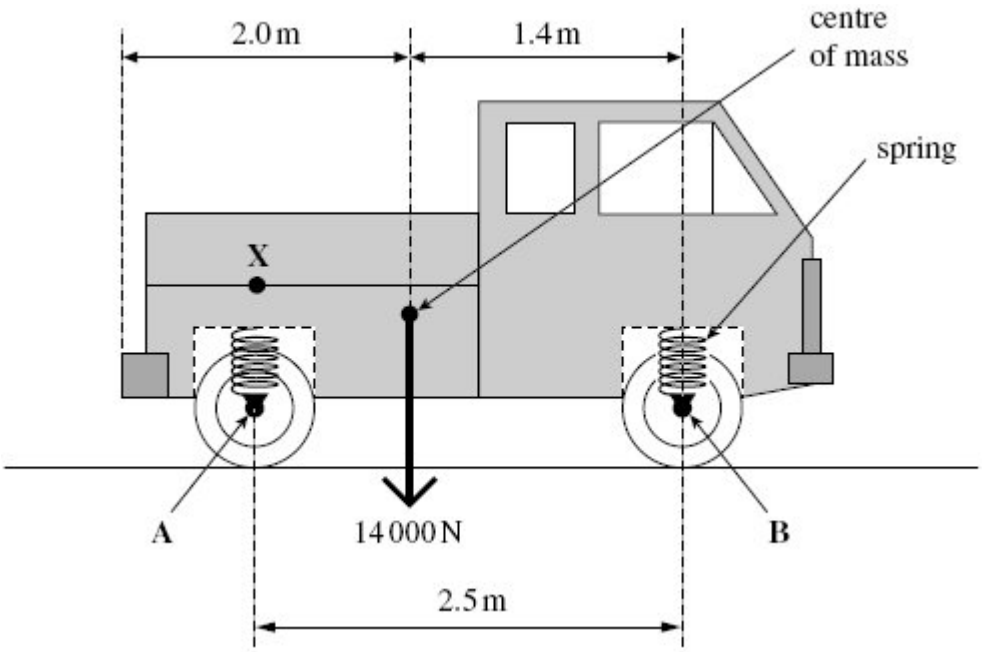
(ii) Just before the container shown in the diagram above was raised from the ship, the length of each lifting cable was 25 m. Show that each cable extended by 17 mm when the container was raised from the ship.

Young modulus of steel = 2.1×10^{11} Pa

(2)

(Total 12 marks)

2 Heavy duty coil springs are used in vehicle suspensions. The pick-up truck shown in the diagram below has a weight of 14 000 N and length of 4.5 m. When carrying no load, the centre of mass is 2.0 m from the rear end. The part of the vehicle shown shaded in grey is supported by four identical springs, one near each wheel.



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

_____

_____

_____

_____

(2)

(ii) State and explain which pair of springs, front or rear, will be compressed the most.

_____

_____

_____

_____

(2)

(iii) By taking moments about axle **B**, calculate the force exerted on the truck by each rear spring.

answer = _____ N

(4)

(b) The spring constant for each of these springs is 100 000 N m^{-1}.

Calculate the distance that each of these rear springs is compressed by this vehicle as shown in the diagram above.

answer = _____ m

(2)

(c) The springs must not be compressed by more than an additional 0.065 m. Calculate the maximum load that could be placed at point **X**, which is directly above the centre of the rear axle **A**, as shown in the diagram above.

answer = _____ N

(2)

(Total 12 marks)

3 Galileo used an inclined plane, similar to the one shown in the figure below, to investigate the motion of falling objects.

(a) Explain why using an inclined plane rather than free fall would produce data which is valid when investigating the motion of a falling object.

_____

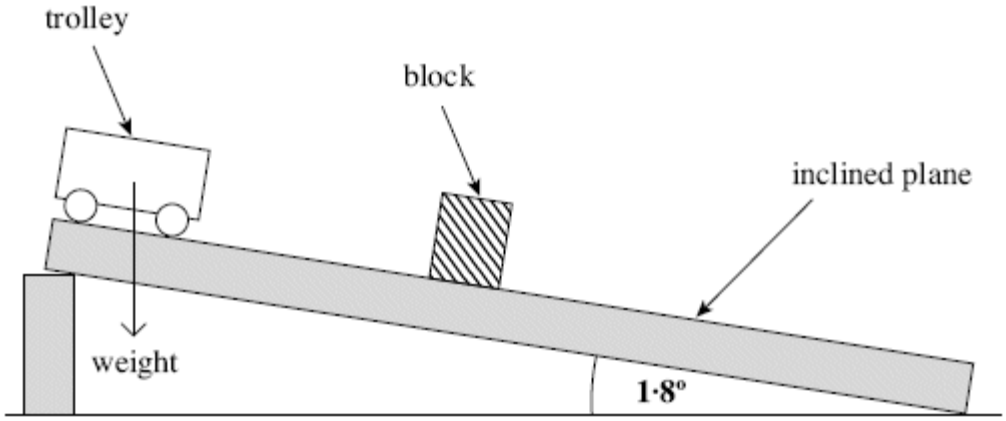
_____

_____

_____

(2)

(b) In a demonstration of Galileo's investigation, the number of swings of a pendulum was used to time a trolley after it was released from rest. A block was positioned to mark the distance that the trolley had travelled after a chosen whole number of swings.
See the figure below.



The mass of the trolley in the figure above is 0.20 kg and the slope is at an angle of 1·8º to the horizontal.

(i) Show that the component of the weight acting along the slope is about 0.06 N.

(2)

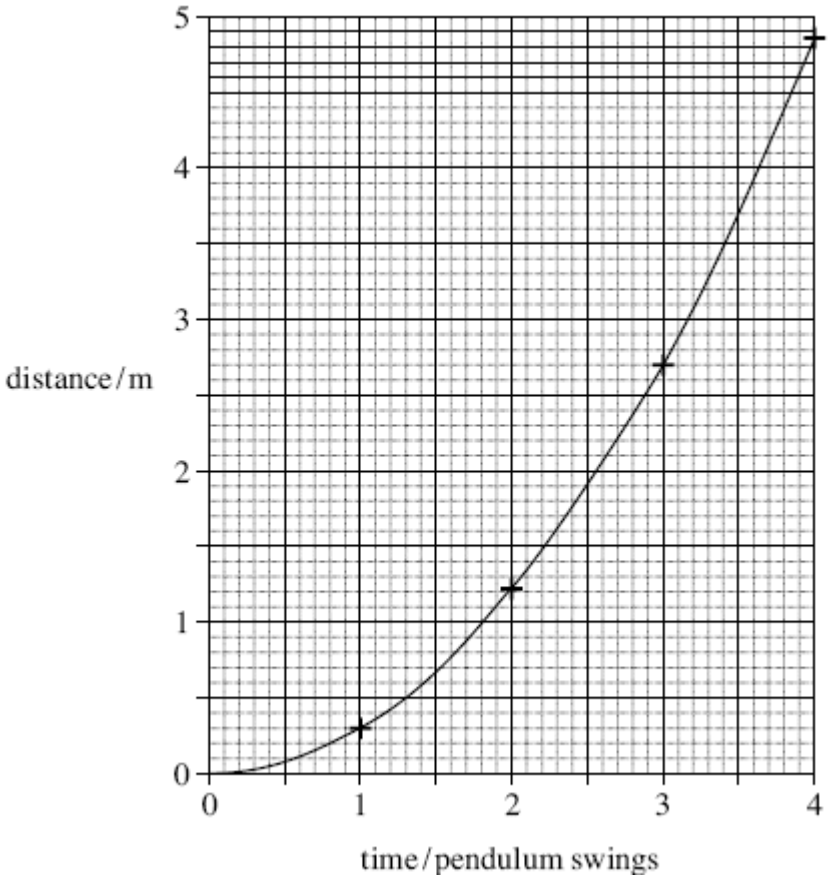
(ii) Calculate the initial acceleration down the slope.

answer = _____ m s^{-2}

(2)

(c) In this experiment, the following data was obtained. A graph of the data is shown below it.

time / pendulum swings	distance travelled /m
1	0.29
2	1.22
3	2.70
4	4.85



From the graph above, state what you would conclude about the motion of the trolley? Give a reason for your answer.

_____

_____

_____

_____

(2)

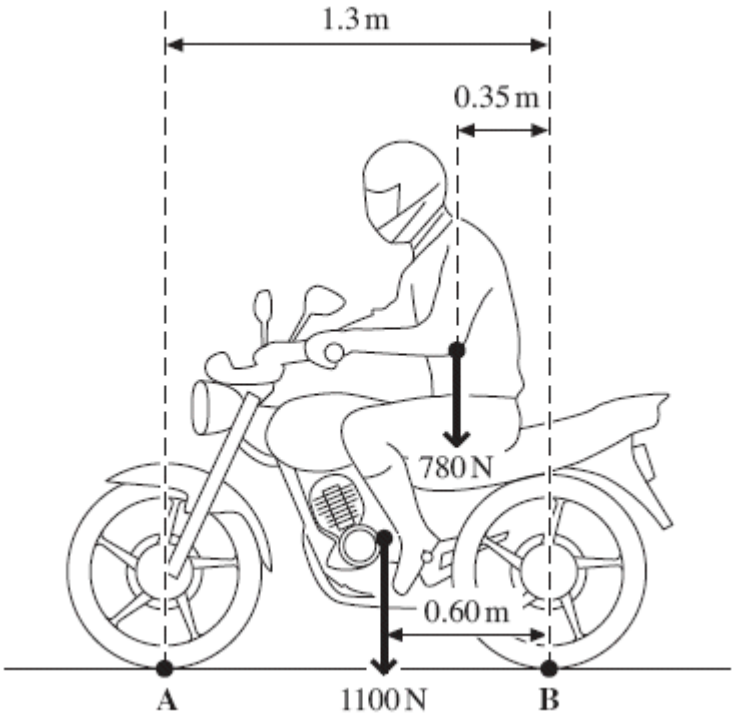
(d) Each complete pendulum swing had a period of 1.4 s. Use the graph above to find the speed of the trolley after it had travelled 3.0 m.

answer = _____ m s^{-1}

(3)

(Total 11 marks)

4 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 m s^{-1}, when travelling on a level road.

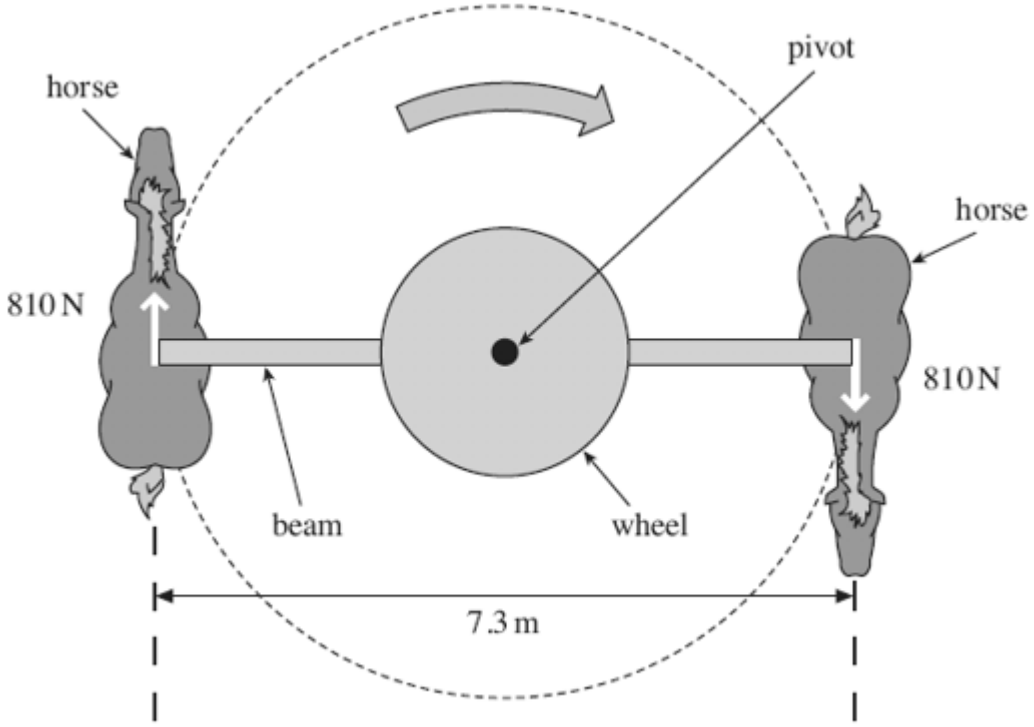
Calculate the total horizontal resistive force for this speed.

answer = _____ N

(2)

(Total 11 marks)

5 Horses were once used to power machinery in factories, mines and mills. The figure below 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.

(i) Define the moment of a couple.

_____

_____

_____

(2)

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

answer = _____

(2)

(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)

(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 the figure above.

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

_____

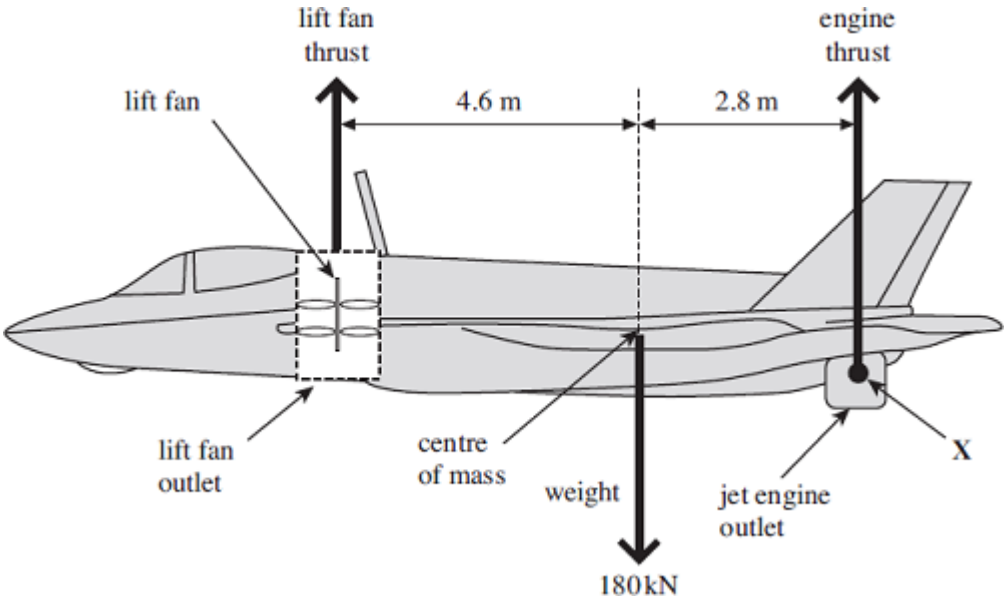
_____

_____

(1)

(Total 8 marks)

6 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.

_____

_____

_____

_____

(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)

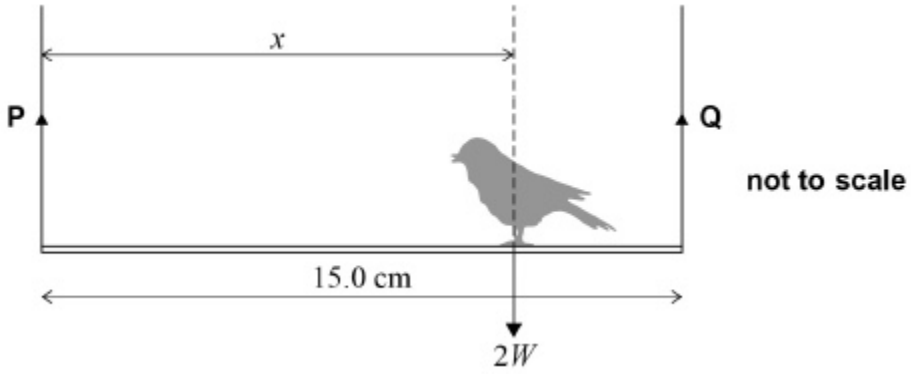
(c) State how a velocity-time graph could be used to find the maximum acceleration.

_____

(1)

(Total 13 marks)

7 A bird sits on a uniform rod suspended from vertical wires **P** and **Q**.



The rod has a weight W and is 15.0 cm long.
The weight of the bird is $2W$ and acts at a distance x from **P**.

What is the value of x when the tension in **P** is half the tension in **Q**?

A 7.50 cm ⬭

B 10.0 cm ⬭

C 11.3 cm ⬭

D 15.0 cm ⬭

(Total 1 mark)