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IB Physics 2 HL Summer Packet

Summer 2017

About 2 hours

77 marks

Please complete this and hand it in on the first day of school. - Mr. Quinn

1. This question is about collisions.

(a) State the principle of conservation of momentum.

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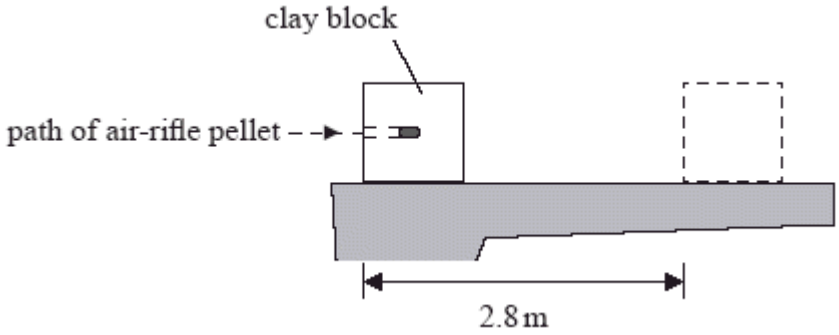
(2)

(b) In an experiment, an air-rifle pellet is fired into a block of modelling clay that rests on a table.



(not to scale)

The air-rifle pellet remains inside the clay block after the impact.

As a result of the collision, the clay block slides along the table in a straight line and comes to rest. Further data relating to the experiment are given below.

Mass of air-rifle pellet	= 2.0 g
Mass of clay block	= 56 g
Velocity of impact of air-rifle pellet	= 140 m s^{-1}
Stopping distance of clay block	= 2.8 m

(i) Show that the initial speed of the clay block after the air-rifle pellet strikes it is 4.8 m s^{-1}.

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(2)

(ii) Calculate the average frictional force that the surface of the table exerts on the clay block whilst the clay block is moving.

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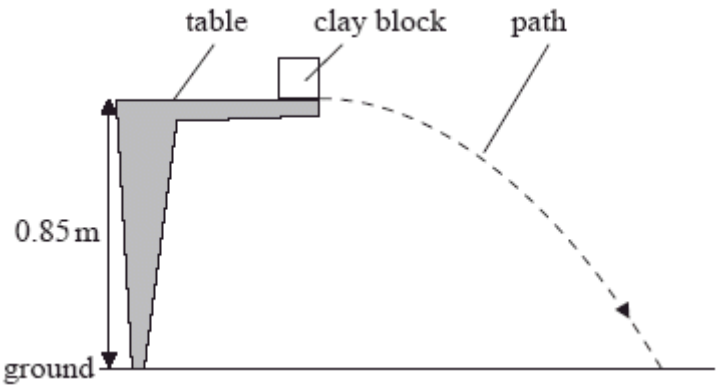
(4)

(c) The experiment is repeated with the clay block placed at the edge of the table so that it is fired away from the table. The initial speed of the clay block is 4.3 m s^{-1} horizontally. The table surface is 0.85 m above the ground.



(not to scale)

(i) Ignoring air resistance, calculate the horizontal distance travelled by the clay block before it strikes the ground.

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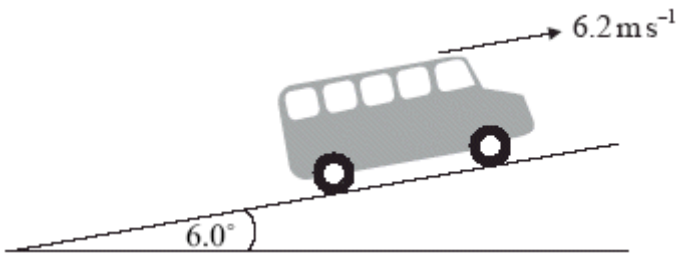
(4)

(ii) The diagram in (c) shows the path of the clay block neglecting air resistance. On the diagram, draw the approximate shape of the path that the clay block will take assuming that air resistance acts on the clay block.

(3)
(Total 15 marks)

2. This question is about power and efficiency.

A bus is travelling at a constant speed of 6.2 m s^{-1} along a section of road that is inclined at an angle of 6.0° to the horizontal.



(a) (i) The bus is represented by the black dot shown below. Draw a labelled sketch to represent the forces acting on the bus.

(4)

(ii) State the value of the rate of change of momentum of the bus.

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(1)

(b) The total output power of the engine of the bus is 70 kW and the efficiency of the engine is 35 %. Calculate the input power to the engine.

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(2)

(c) The mass of the bus is 8.5×10^3 kg. Determine the rate of increase of gravitational potential energy of the bus.

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(3)

(d) Using your answer to (c) and the data in (b), estimate the magnitude of the resistive forces acting on the bus.

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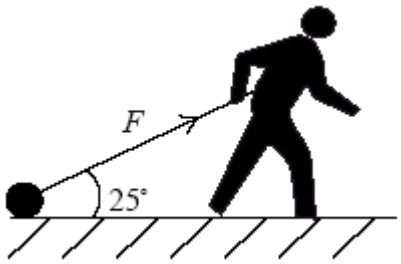
(3)
(Total 13 marks)

3. This question is about forces.

An athlete trains by dragging a heavy load across a rough horizontal surface.



The athlete exerts a force of magnitude *F* on the load at an angle of 25° to the horizontal.

(a) Once the load is moving at a steady speed, the average horizontal frictional force acting on the load is 470 N.

Calculate the average value of *F* that will enable the load to move at constant speed.

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(2)

(b) The load is moved a horizontal distance of 2.5 km in 1.2 hours.

Calculate

(i) the work done on the load by the force *F*.

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(2)

(ii) the minimum average power required to move the load.

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(2)

(c) The athlete pulls the load uphill at the same speed as in part (a).

Explain, in terms of energy changes, why the minimum average power required is greater than in (b)(ii).

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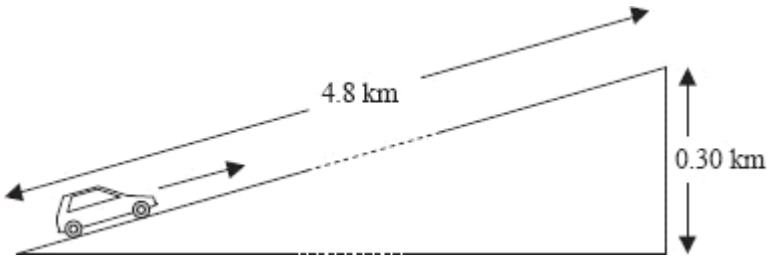
(2)

(Total 8 marks)

4. Mechanical power

(a) A car drives up a straight incline that is 4.8 km long. The total height of the incline is 0.30 km.



The car moves up the incline at a steady speed of 16 m s^{-1}. During the climb, the average friction force acting on the car is 5.0×10^2 N. The total weight of the car and the driver is 1.2×10^4 N.

(i) Determine the time it takes the car to travel from the bottom to the top of the incline.

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(2)

(ii) Determine the work done against the gravitational force in travelling from the bottom to the top of the incline.

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(1)

(iii) Using your answers to (a)(i) and (a)(ii), calculate a value for the minimum power output of the car engine needed to move the car from the bottom to the top of the incline.

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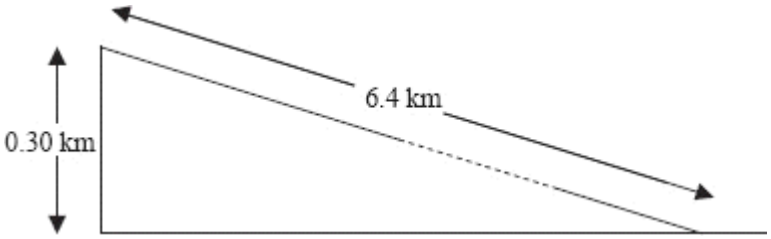
(4)

(b) From the top of the incline, the road continues downwards in a straight line. At the point where the road starts to go downwards, the driver of the car in (a), stops the car to look at the view. In continuing his journey, the driver decides to save fuel. He switches off the engine and allows the car to move freely down the hill. The car descends a height of 0.30 km in a distance of 6.4 km before levelling out.



The average resistive force acting on the car is 5.0×10^2 N.

Estimate

(i) the acceleration of the car down the incline.

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(5)

(ii) the speed of the car at the bottom of the incline.

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(2)

(c) In fact, for the last few hundred metres of its journey down the hill, the car travels at constant speed. State the value of the frictional force acting on the car whilst it is moving at constant speed.

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(1)

(Total 15 marks)

5. This question is about impulse.

(a) A net force of magnitude *F* acts on a body. Define the *impulse I* of the force.

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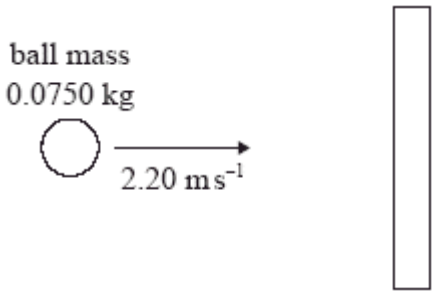
(1)

(b) A ball of mass 0.0750 kg is travelling horizontally with a speed of 2.20 m s^{-1}. It strikes a vertical wall and rebounds horizontally.



Due to the collision with the wall, 20 % of the ball's initial kinetic energy is dissipated.

(i) Show that the ball rebounds from the wall with a speed of 1.97 m s^{-1}.

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(2)

(ii) Show that the impulse given to the ball by the wall is 0.313 N s.

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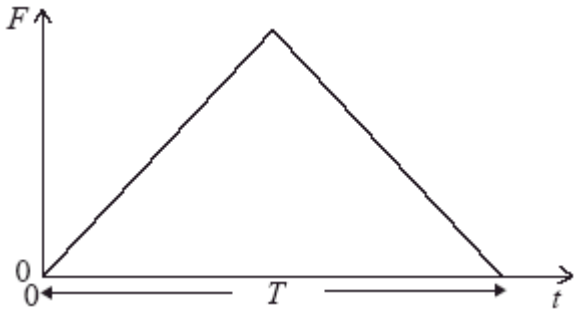
(2)

(c) The ball strikes the wall at time $t = 0$ and leaves the wall at time $t = T$.

The sketch graph shows how the force F that the wall exerts on the ball is assumed to vary with time t.



The time T is measured electronically to equal 0.0894 s.

Use the impulse given in (b)(ii) to estimate the average value of F.

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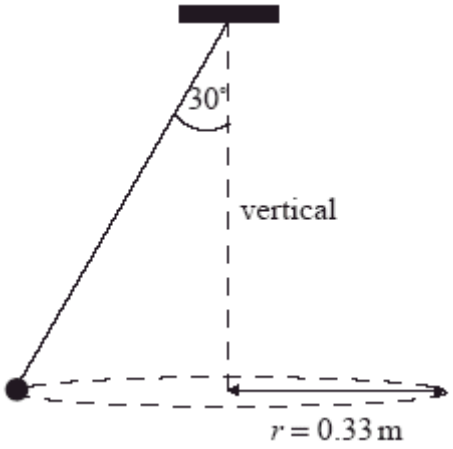
(4)
(Total 9 marks)

6. This question is about circular motion.

A ball of mass 0.25 kg is attached to a string and is made to rotate with constant speed v along a horizontal circle of radius r = 0.33 m. The string is attached to the ceiling and makes an angle of 30° with the vertical.



(a) (i) On the diagram above, draw and label arrows to represent the forces on the ball in the position shown.

(2)

(ii) State and explain whether the ball is in equilibrium.

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(2)

(b) Determine the speed of rotation of the ball.

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(3)

(Total 7 marks)

7. This question is about forces.

A solid iron ball of mass 770 kg is used on a building site. The ball is suspended by a rope from a crane. The distance from the point of suspension to the centre of mass of the ball is 12 m.

(a) Calculate the tension in the rope when the ball hangs vertical and stationary.

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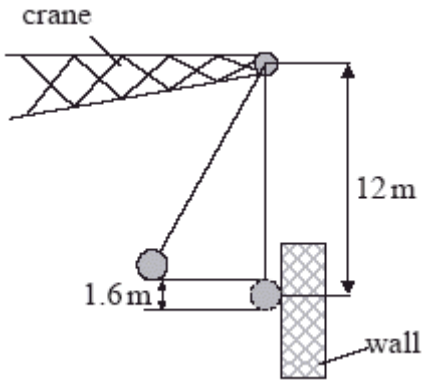
(1)

(b) The ball is pulled back from the vertical and then released. It falls through a vertical height of 1.6 m and strikes a wall.



(i) Calculate the speed of the ball just before impact.

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(2)

(ii) Calculate the tension in the rope just before impact.

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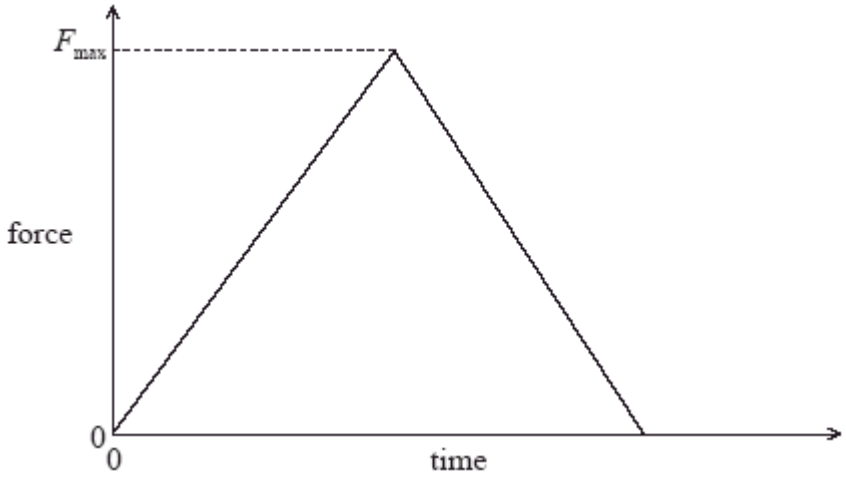
(3)

(c) The ball is brought to rest in 0.15 s. The sketch graph below shows how the force the ball exerts on the wall varies with time.



(i) State what quantity is represented by the area under the graph.

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(1)

(ii) Determine the maximum force F_{max} exerted by the ball on the wall.

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(3)

(Total 10 marks)