

Name _____

Date _____

Score: _____ / 41

70 minutes · 41 marks · calculator and data booklet allowed

- Answer all the questions in the spaces provided.
- Show all your working. Marks are given for correct method.
- The marks for each part are shown in brackets [].
- Take $g = 9.8 \text{ m s}^{-2}$.

1. Measuring the viscosity of oil [12 marks]

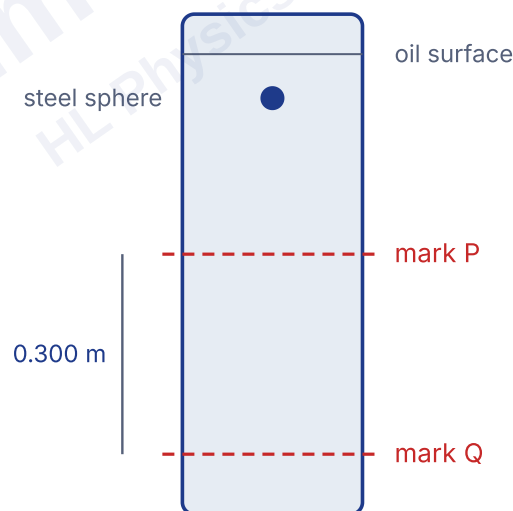
A student measures the viscosity of an oil. A small steel sphere is released from rest just below the surface of the oil in a tall tube. The time for the sphere to fall between two marks, P and Q, is measured.

The following data are given:

radius of the sphere = 2.00 mm

density of steel = 7800 kg m^{-3}

density of the oil = 880 kg m^{-3}



- (a) **Draw** a free-body diagram of the forces acting on the sphere when it falls at terminal speed. [2]



- (b) **Show that** the weight of the sphere is about 2.6×10^{-3} N. [1]

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- (c) **Calculate** the buoyancy force on the sphere. [1]

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- (d) The sphere falls the 0.300 m from P to Q in 10.7 s at constant speed. **Determine** the viscosity of the oil. [3]

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- (e) **State** how the acceleration of the sphere changes from the moment it is released until it reaches mark P. [1]

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(f) **Outline** why the marks P and Q are placed well below the surface of the oil.

[2]

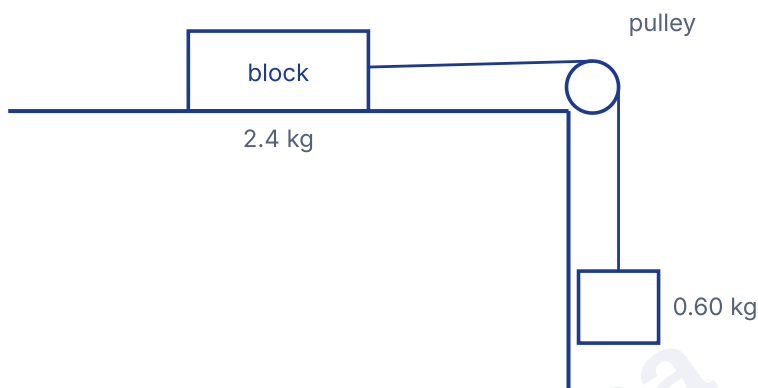
(g) The experiment is repeated with the oil at a higher temperature. **Explain** the effect on the time to fall from P to Q.

[2]

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2. A block pulled by a hanging mass [10 marks]

A block of mass 2.4 kg on a horizontal table is joined by a light string over a smooth pulley to a hanging mass of 0.60 kg. The masses are released from rest.



- (a) The table is smooth. **Show that** the acceleration of the block is about 2 m s^{-2} . [2]

- (b) For the smooth table, **calculate** the tension in the string. [1]

- (c) **Explain** why the tension is less than the weight of the hanging mass. [2]

- (d) The table is now replaced by a rough surface. The coefficient of static friction between the block and the surface is 0.30. [2]

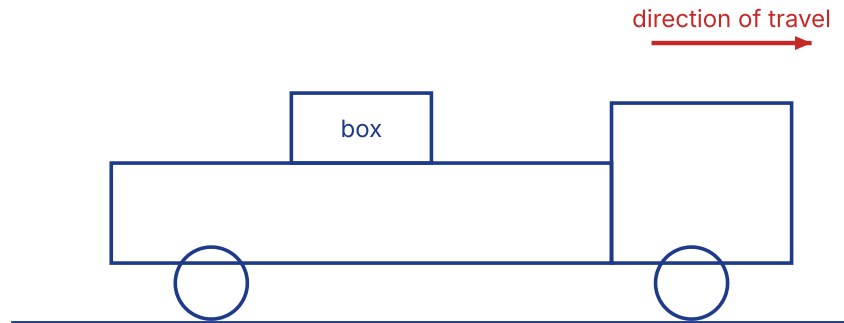
Show that the block does not move when it is released.

- (e) The hanging mass is increased to 1.2 kg. The coefficient of dynamic friction between the block and the surface is 0.25. **Determine** the acceleration of the block. [3]

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3. A box on a truck [9 marks]

A box of mass 30 kg rests on the flat, horizontal back of a truck. The coefficient of static friction between the box and the truck is 0.40.



- (a) The truck accelerates forwards and the box moves with the truck. **Identify** the force that accelerates the box and **state** its direction. [2]

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- (b) **Calculate** the largest acceleration of the truck for which the box does not slide. [2]

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- (c) The friction force on the box forms a pair with another force according to Newton's third law. **State** two properties of this other force, other than its size. [2]

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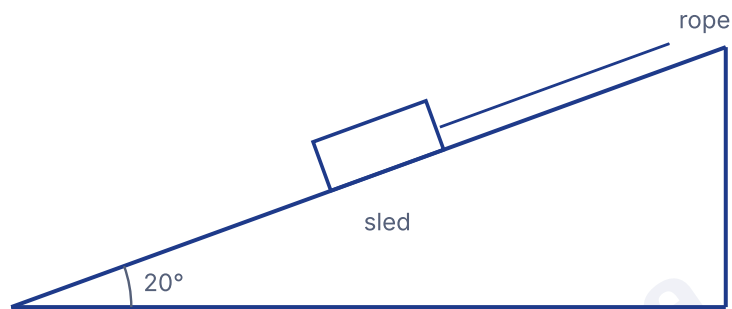
- (d) The truck is travelling at 15 m s^{-1} . It brakes uniformly and stops in a distance of 25 m. [2]
Determine whether the box slides on the truck.

- (e) **Explain**, with reference to Newton's first law, the direction in which the box slides relative to the truck in (d). [1]

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4. A sled on a slope [10 marks]

A sled of mass 15 kg is pulled up a snowy slope by a rope that is parallel to the slope. The slope makes an angle of 20° with the horizontal. The coefficient of dynamic friction between the sled and the snow is 0.10.



- (a) **Draw** a free-body diagram of the forces acting on the sled while it is pulled up the slope.

[2]

A large empty rectangular box for drawing the free-body diagram. A faint watermark 'Ahmed Gomaa HL Physics Notebook' is visible across the box.

- (b) **Show that** the normal force on the sled is about 140 N.

[1]

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- (c) The sled moves up the slope at constant speed. **Calculate** the tension in the rope.

[2]

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- (d) The rope breaks when the sled is moving up the slope at 2.0 m s^{-1} . **Calculate** the magnitude of the deceleration of the sled. [2]

- (e) **Calculate** the distance the sled moves up the slope after the rope breaks. [1]

- (f) The coefficient of static friction between the sled and the snow is 0.15. **Determine** whether the sled stays at rest when it stops. [2]

End of paper

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