BINDURA UNIVERSITY OF SCIENCE EDUCATION

Faculty of Science Education

Department of Mathematics and Science Education

Diploma in Science-Physics

DP001-Mechanics/PH001-Introductory Mechanics

Duration: Three (3) Hours

INTSRUCTIONS

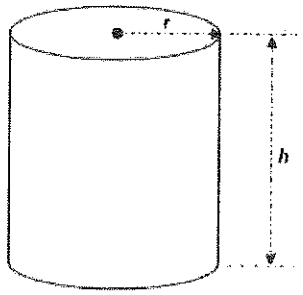
- *Answer ALL questions in Section A and any THREE questions from Section B. Section A carries 40 marks and each question of Section B carries 20 marks.*
- *Show ALL formulae and substitutions in ALL calculations.*
- *Leave your answers correct to 2 decimal places*

You may not start to read the questions printed on the subsequent pages until instructed to do so by the Invigilator.

SECTION A (40 Marks)

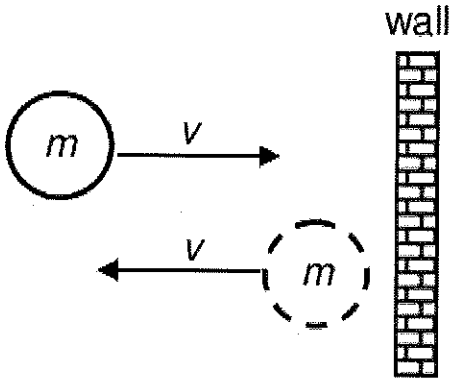
QUESTION 1 [40 MARKS]

a) The dimensions of a cylindrical can represented below are; $height = (200 \pm 0.5) \times mm$ and $radius = (50 \pm 0.5)mm$;



Calculate its volume including the uncertainty $(V \pm \Delta V)$. (4)

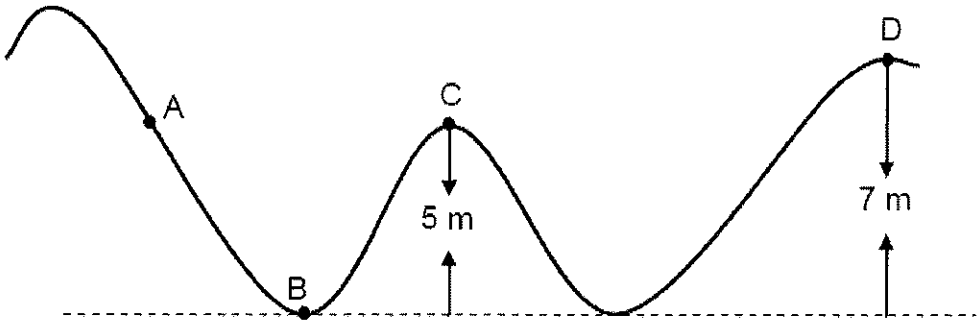
b) A ball of mass m strikes a wall perpendicularly at a speed v. Immediately after the collision the ball moves in the opposite direction at the same speed v, as shown in the diagram below.



Show that the magnitude of the change in momentum of the ball is 2mv. (3)

c) Friction is a natural phenomenon that is experienced in our daily lives.
   i. Define the term 'friction' (1)
   ii. In table form, give two (2) examples each of cases where friction is useful and when it is a nuisance. (4)

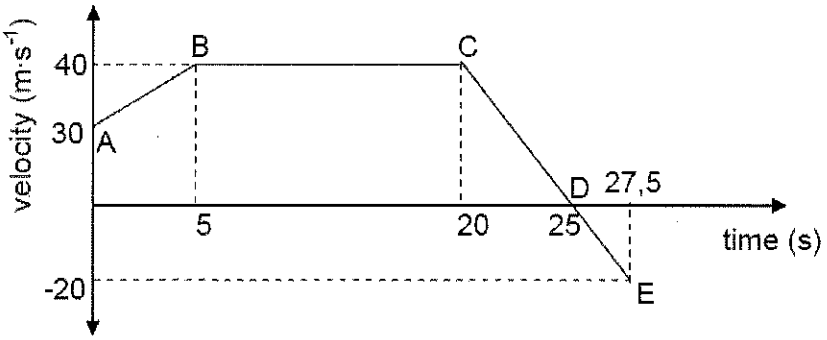
d) A steel ball of mass 5kg is rolling over a frictionless surface, as shown below. When the ball reaches point A it has mechanical energy of 250J. (The sketch is NOT drawn to scale.)

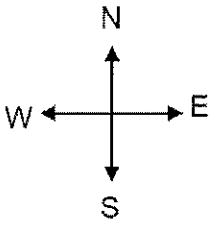


i. State the principle of conservation of mechanical energy in words and use it to find the kinetic energy of the steel ball at point B as well as speed of the steel ball at the instant it reaches point C (9)

ii. Determine whether the mechanical energy acquired by the ball at point A will be enough to carry the ball over point D. Show ALL calculations. (4)

e) The velocity versus time graph for a racing car moving eastwards, is shown below.





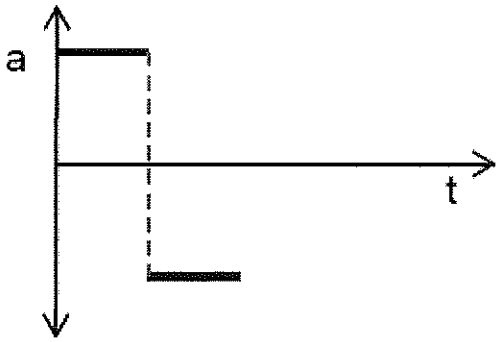
i. What is the initial velocity of the car. (2)

ii. Write down the speed of the car at time t = 10 s. (2)

iii. Without any calculation, compare the magnitude of the acceleration of the car in part DE with that of part CD of the journey. Write only GREATER THAN, LESS THAN or EQUAL TO. Give a reason for your answer. (2)

iv. Determine the total displacement for the motion of the car. (7)

In another incident, the acceleration-time graph of a school bus is shown below.



v. Sketch the corresponding velocity-time graph for the motion of this object. (2)

SECTION B (60 Marks)

QUESTION 2 [20 MARKS]

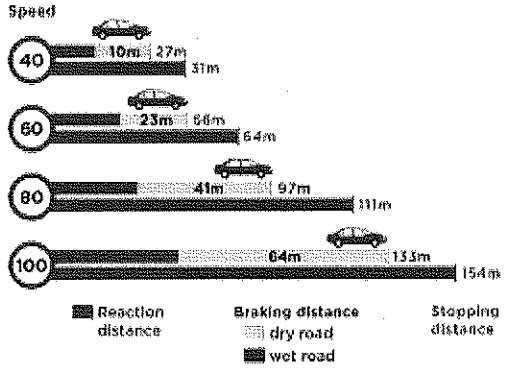
A car accelerates from rest at 15 $m \cdot s^{-2}$ for 2s on a horizontal road.

a) Calculate the:

i. Distance covered by the car (4)

ii. Velocity of the car (4)

Drivers are encouraged to avoid tailgating, but rather maintain a 'safe following distance' when driving behind a mobile vehicle.



While travelling at a constant velocity of 108 $km \cdot h^{-1}$, the car driver notices a sign warning motorists to keep a safe 2-second reaction distance. At that instant the car is 80 m behind a truck that is travelling at a constant velocity of 90 $km \cdot h^{-1}$.

b) Briefly explain the meaning of a 'safe 2-second following distance'. (2)

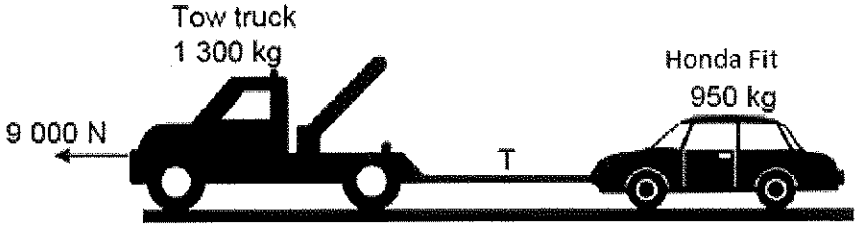
c) Calculate the safe 2-second following distance behind the truck. (6)

d) Calculate how long it will take the motorist to get to a safe 2-second reaction distance behind the truck. (4)

QUESTION 3 [20 MARKS]

Recommendations are that when towing, your tow vehicle must be capable of hauling its own weight, the weight of everyone and everything inside it, the weight of the trailer it's pulling, and the weight of everything on the trailer.

One such tow truck pulls a Honda Fit car along a gravel road. The force applied by the engine of the tow truck is 9 000 N. The mass of the tow truck is 1 300 kg and the mass of the car is 950 kg. The vehicles are connected to each other by an inelastic tow bar of negligible mass. See the diagram below.



The tow truck and car move at a **CONSTANT VELOCITY.**

a) Define the term frictional force. (2)

b) NAME AND STATE the law that explains why the force exerted by the tow truck on the car is the same as the force exerted by the car on the tow truck. (3)

c) Draw a labelled free-body diagram indicating all the forces acting on the tow truck. (5)

d) If the coefficient of kinetic friction between the tow-truck tyres and the road surface is 0,45, calculate the:

(i) Magnitude of the tension in the tow bar (5)

(ii) Coefficient of kinetic friction between the CAR tyres and the road surface (5)

QUESTION 4 [20 MARKS]

Car A (mass = 2 200 kg) which is travelling at a velocity of 14 $m \cdot s^{-1}$ in an eastern direction loses control and crashes head-on a second oncoming car, Car B (mass = 1 200 kg), which is travelling at a velocity of 40 $m \cdot s^{-1}$ in a western direction. The two cars become entwined with the impact and continue to move together.

a) During collision sound and heat are released. What type of collision is described here. (2)

b) State the principle of conservation of linear momentum. (2)

c) Calculate the velocity of the wreckage after the collision (12)

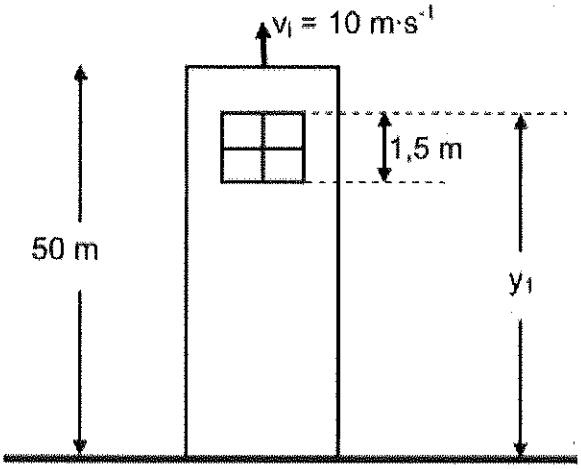
d) A learner states that it is less dangerous to be in a heavier car during a collision. Answer the following questions relating to this statement.

i. How will the change in momentum of the heavier car A compare to that of the lighter car B? (2)

ii. Use principles of Physics and explain why the statement made by the learner could be correct. (2)

QUESTION 5 [20 MARKS]

While playing, Ropafadzo throws a stone vertically upward at a velocity of $10m \cdot s^{-1}$ from the top of a tower of height 50 m. After some time the stone passes the edge of the tower and strikes the ground below the tower. Ignore the effects of friction.



a) Briefly explain why air resistance is assumed negligible. (2)

b) Calculate the:

(i) Time taken by the stone to reach its maximum height above the ground (4)

(ii) Maximum height that the stone reaches above the ground (4)

c) USING THE GROUND AS REFERENCE (zero position), sketch a position-time graph for the entire motion of the stone. (3)

d) On its way down, the stone takes 0,1s to pass a window of length 1,5m, as shown in the diagram above. Calculate the distance (y_i) from the top of the window to the ground. (7)

END OF PAPER

USEFUL FORMULAE AND CONSTANTS

$v_f = v_i + a\Delta t$	$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$
$v_f^2 = v_i^2 + 2a\Delta x$	$\Delta x = \left(\frac{v_f + v_i}{2}\right)\Delta t$

$F_{net} = ma$	$w = mg$
$F = \frac{Gm_1m_2}{r^2}$	$\mu_s = \frac{f_{s(max)}}{N}$
$\mu_k = \frac{f_k}{N}$	

NAME	SYMBOL	VALUE
Acceleration due to gravity	g	9,8 $m\cdot s^{-2}$
Gravitational constant	G	6,67 x 10^{-11} $N\cdot m^2\cdot kg^{-2}$
Radius of Earth	R_E	6,38 x 10^6 m
Mass of the earth	M	5,98 x 10^{24} kg