BINDURA UNIVERSITY OF SCIENCE EDUCATION

Faculty of Science Education

Department of Mathematics and Science ...

Diploma in Science Education (Physics)

PH001-Introductory Mechanics/DP001-Mechanics

Duration: Three (3) Hours

100 MARKS

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.*
- *Round off your final numerical answers to TWO (2) decimal places.*

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

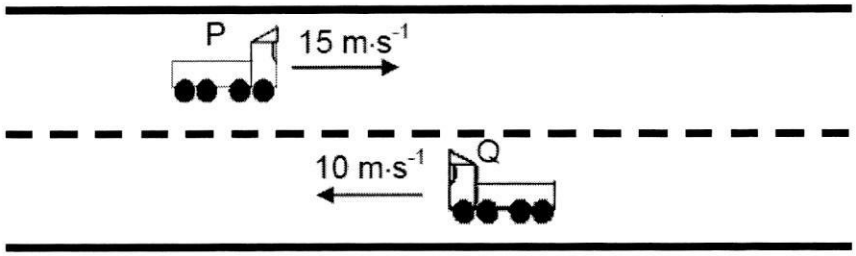
SECTION A (40 Marks)

a) ERRORS AND UNCERTAINTIES [4 MARKS]

The dimensions of a rectangle are; $length = (200 \pm 0.5) \times mm$ and $width = (150 \pm 0.5)mm$. Calculate its perimeter (in centimeters) including the uncertainty. (4)

b) KINEMATICS IN ONE DIMENSION [3 MARKS]

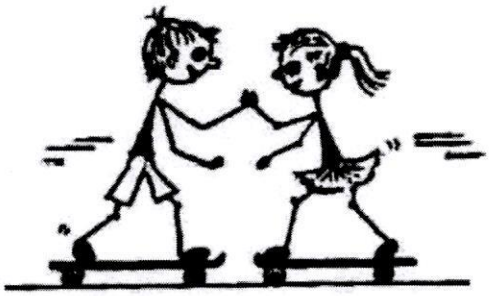
The diagram below shows two trucks, **P** and **Q**, travelling in opposite directions along a straight level road. Truck **P** travels at $15ms^{-1}$ and truck **Q** travels at $10ms^{-1}$.



A passenger on truck P will observe truck Q travelling at what velocity? (3)

c) DYNAMICS [5 MARKS]

Nancy, mass m, and Gringo, mass $2m$, are facing each other while playing with their roller skates. They push off against each other with their hands. Gringo experiences a force F and an acceleration a towards the left.

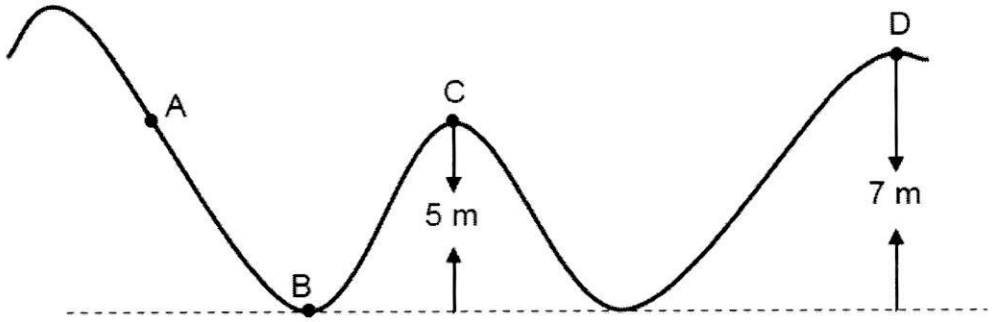


i. Ignoring the effects of friction, show that the expression that best describe the magnitude of acceleration experienced by the girl (a_g) is $a_g = 2a$. (3)

ii. Explain how friction affects your answer in i). (2)

d) WORK ENERGY AND POWER [13 MARKS]

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.)

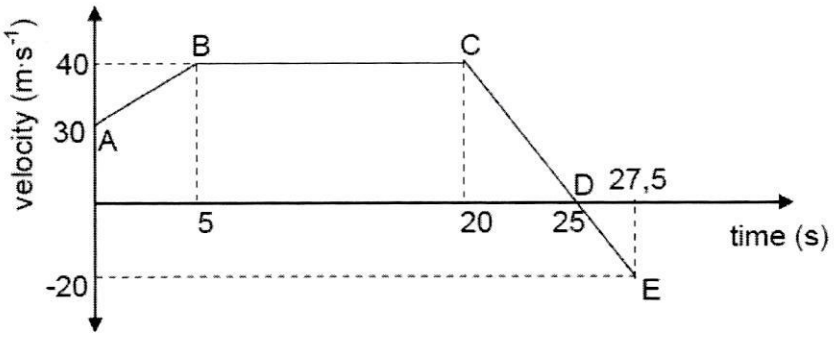


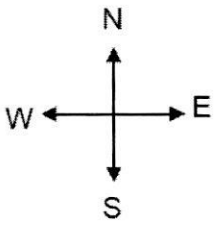
i. State the principle of conservation of mechanical energy in words and use it to find the kinetic energy of the steel ball at point B as well as speed of the steel ball at the instant it reaches point C (9)

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) KINEMATICS IN ONE DIMENSION [15 MARKS]

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





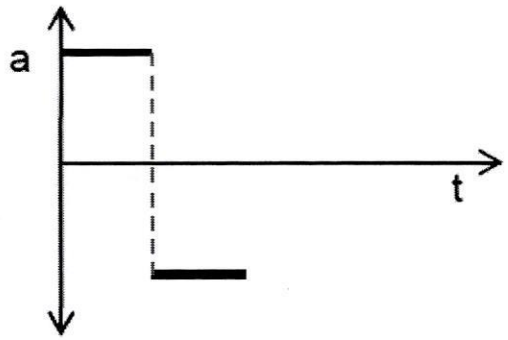
i. What is the initial velocity of the car. (2)

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 DYNAMICS [20 Marks]

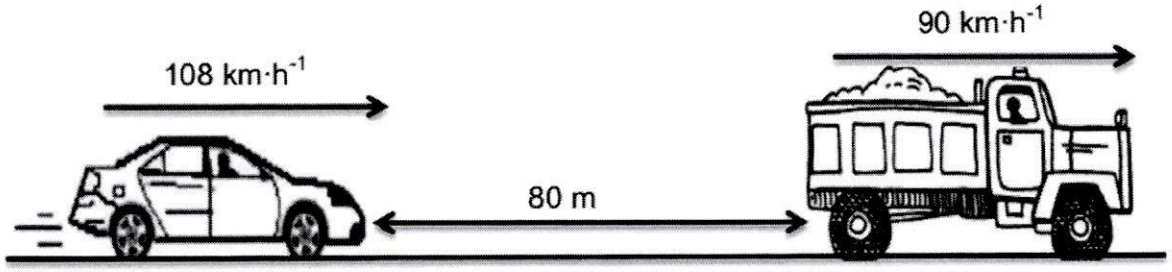
A car accelerates from rest at 15 $m \cdot s^{-2}$ for 2s on a horizontal road.

a) Calculate the:

i. Distance covered by the car (4)

ii. Velocity of the car (4)

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 $km \cdot h^{-1}$.



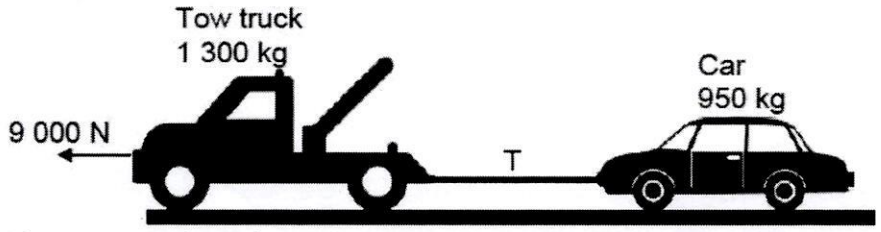
c) Briefly explain the meaning of a 'safe 2-second following distance'. (2)

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

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

QUESTION 3: DYNAMICS [20 MARKS]

A tow truck pulls a 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)

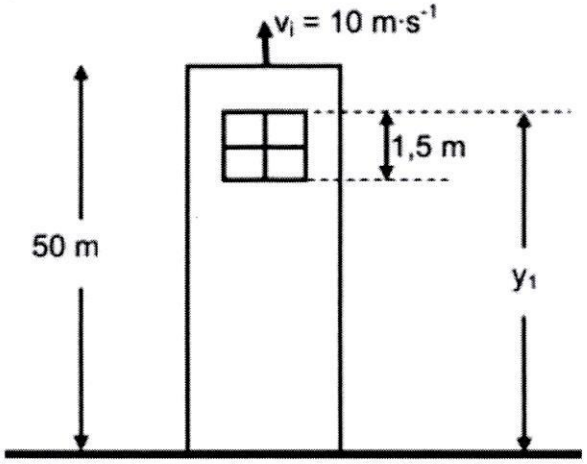
QUESTION 4: KINEMATICS [20 MARKS]

A van is traveling at a constant speed of $54km \cdot h^{-1}$ in a $40km \cdot h^{-1}$ zone. A policeman starts his car from rest just as the van passes him. The police car accelerates at $2m \cdot s^{-2}$ until it reaches a maximum velocity of $20m \cdot s^{-1}$. The policeman then continues driving at this constant velocity.

a) Define the term acceleration. (2)
b) Convert $54km \cdot h^{-1}$ to metres per second ($m \cdot s^{-2}$). (3)
c) Calculate the time it takes the police car to reach its maximum velocity. (4)
d) Calculate which vehicle (the van or the police car) is ahead at the time calculated in c) (5)
e) Calculate how far the police car has to travel before it catches up with the van. (5)
f) 3.6 Write down the total time taken by the police car to catch up with the van. (1)

QUESTION 5: VERTICAL PROJECTILE MOTION [20 MARKS]

A stone is thrown 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) Define the term, free fall. (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	$6,67 \times 10^{-11}\ N\cdot m^2\cdot kg^{-2}$
Radius of Earth	R_E	$6,38 \times 10^6\ m$
Mass of the earth	M	$5,98 \times 10^{24}\ kg$