St Norbert College

11 ATAR PHYSICS

Unit 2 – Linear Motion and Force

Task 9: Topic Test

Assessment type: Tests and Examinations
Year weighting: 6%

Student name:	
TOTAL	**/ 50**

Time allowed for this paper
Working time for paper: fifty (50) minutes

Materials required/recommended for this paper
To be provided by the supervisor
This Question/Answer Booklet
Formulae and Data Booklet

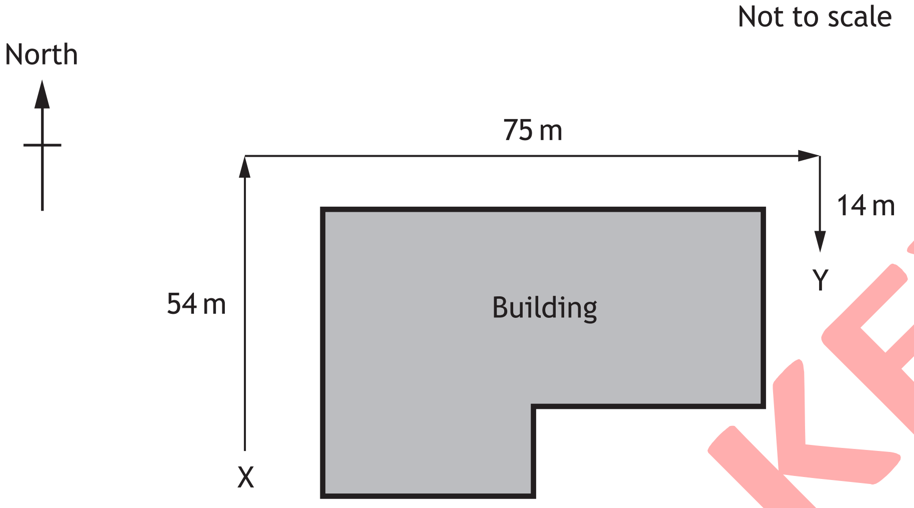
To be provided by the candidate
Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction tape/fluid, eraser, ruler, highlighters
Special items non-programmable calculators approved for use in the WACE examinations, drawing templates, drawing compass and protractor

Important note to candidates
No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

MARKING KEY

Question 1 **(9 marks)**

A student walks around a building from point X to point Y.



(a) Determine:

(i) the magnitude of the displacement of the student from point X to point Y. (2 marks)

Using Pythagoras:

Resultant^2 = $40^2 + 75^2$ (1)

Resultant = 85 m (1)

(ii) the direction of displacement of the student from point X to point Y. (2 marks)

$\tan\theta = \frac{75}{40}$ (1)

$(\theta = 62°)$

direction = 062 (1)

MARKING KEY

(b) The student takes 68 s to travel from point X to point Y.

(i) Determine the average velocity of the student from point X to point Y.

(3 marks)

$\bar{v} = \frac{s}{t}$ (1)

$\bar{v} = \frac{85}{68}$ (1)

$\bar{v} = 1{\cdot}3\,\mathrm{m\,s^{-1}}$ at bearing 062 (1)

(ii) The student states that their average speed between point X and point Y is greater than the magnitude of their average velocity between point X and point Y.

(2 marks)

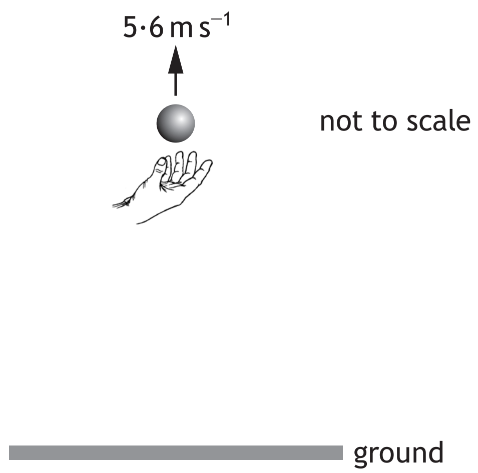
distance is greater (than displacement) (1)

same time (1)

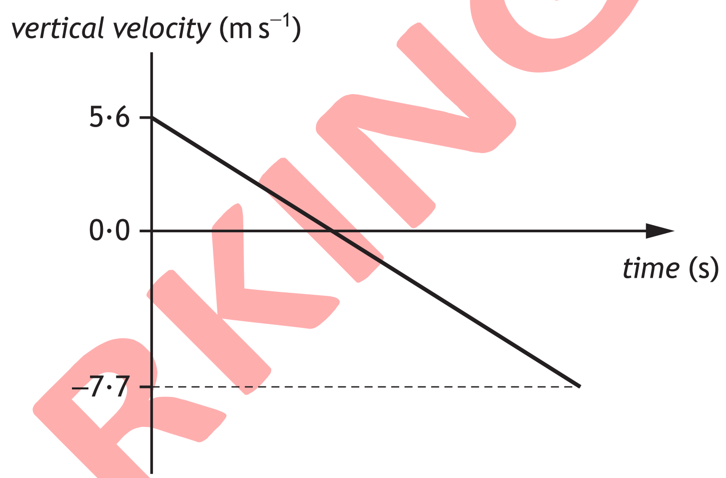
MARKING KEY

Question 2 **(9 marks)**

A ball is thrown vertically upwards. The ball is above the ground when released.



(a) The graph shows how the vertical velocity of the ball varies with time from the instant it is released until just before it hits the ground. The effects of air resistance can be ignored.



(i) Calculate the time taken for the ball to reach its maximum height. (3 marks)

$v = u + at$	1
$0 = 5 \cdot 6 + (-9 \cdot 8)t$	1
$t = 0 \cdot 57 \text{ s}$	1

MARKING KEY

(ii) Calculate the distance the ball falls from its maximum height to the ground.
(3 marks)

$v^2 = u^2 + 2as$ 1

$(-7\cdot7)^2 = 0^2 + 2 \times (-9\cdot8)s$ 1

$s = -3\cdot0\,\mathrm{m}$ 1

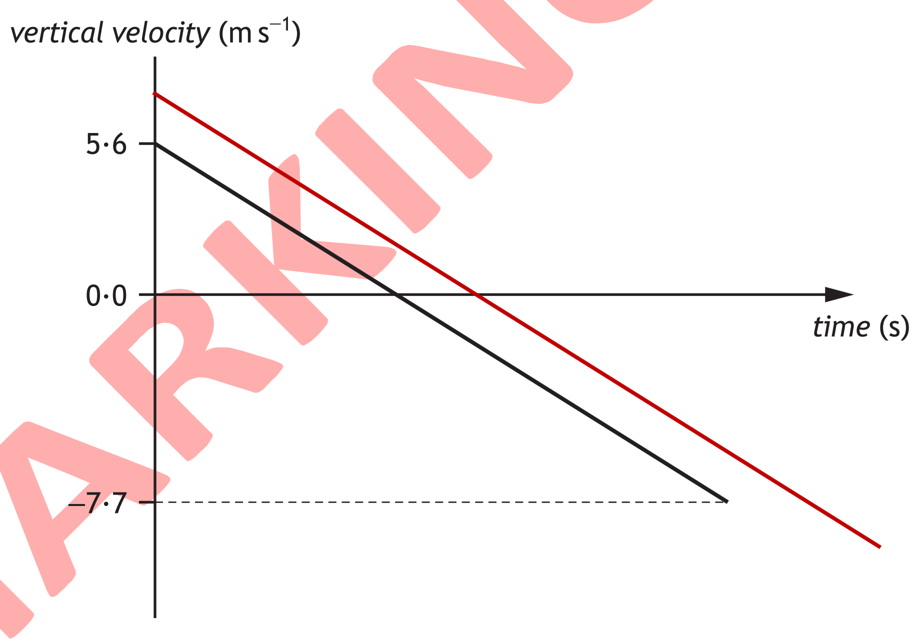
(Distance = 3·0 m)

(b) The ball is now thrown vertically upwards from the same height with a greater initial vertical velocity.

Add a line to the graph below to show how the vertical velocity of the ball varies with time from the instant it is released until just before it hits the ground.

The effects of air resistance can be ignored.

Additional numerical values on the axes are not required. (3 marks)



Starting point greater than 5·6 1
Final point beyond -7·7 1
Acceptably parallel line 1

MARKING KEY

Question 3 **(6 marks)**

A weightlifter applies an upwards force of 1176 N to a barbell to hold it in a stationary position as shown.

(a) Describe how the upward force exerted by the weightlifter on the barbell compares to the weight of the barbell. (1 mark)

Equal in size opposite in direction

(b) Show that the mass of the barbell is 120 kg. (1 mark)

$$W = mg$$
$$1176 = m \times 9{\cdot}8$$
$$m = 120 \text{ kg}$$

(c) The weightlifter increases the upward force on the barbell to 1344 N in order to lift the barbell above their head. Calculate the initial acceleration of the barbell. (4 marks)

$F = 1344 - 1176 = 168$ (N) (1)

$F = ma$ (1)

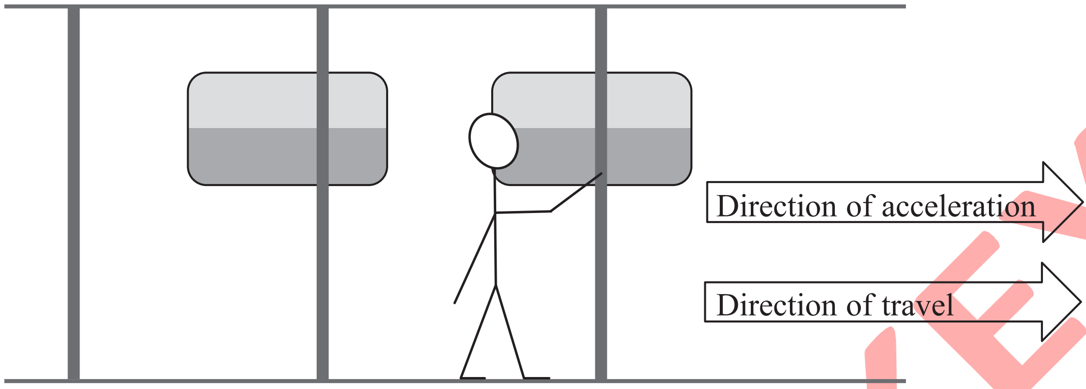
$168 = 120 \times a$ (1)

$a = 1{\cdot}4 \text{ m s}^{-2}$ (1)

MARKING KEY

Question 4 **(5 marks)**

A passenger is standing in a stationary train. As the train leaves the station, the passenger holds on to a vertical support as the train accelerates. This prevents the passenger falling backwards.



With reference to Newton's laws of motion, explain why holding on to a vertical support prevents the passenger falling backwards.

Man pulls (backward) on the support (1)

Due to N3 the support exerts a (opposite) force on the man (1)

This force is a resultant/unbalanced/net force on man (1)

Due to N1/N2 the man will accelerate (1)

With the same acceleration/speed/velocity as the train (1)

MARKING KEY

(5)

The first law now shows that because a force is applied to him he will accelerate with the train as ΣF > 0. The passenger is pulled by the train whilst holding onto the rail, this resultant force allows him to accelerate at the same rate as the train. (So he doesn't fall back). Newtons Third law describes pairs of forces. As the train exerts a force on his arm, his arm also exerts a force on the train. These forces are equal in magnitude, the same type of force, opposite in direction AND ACT on DIFFERENT bodies. because these forces act on different bodies there is a resultant force on the

(Total for Question 17 = 8 marks)

man ∴ he will accelerate with the train. This is a "third law pair". The second law also states that the acceleration is ~~direction~~ directly proportional to the resultant force and that the acceleration acts in the same direction as the resultant force. (inversely prop to mass too!)

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Question 5 **(11 marks)**

A boy on a board B slides down a slope, as shown in Fig. 5.1.

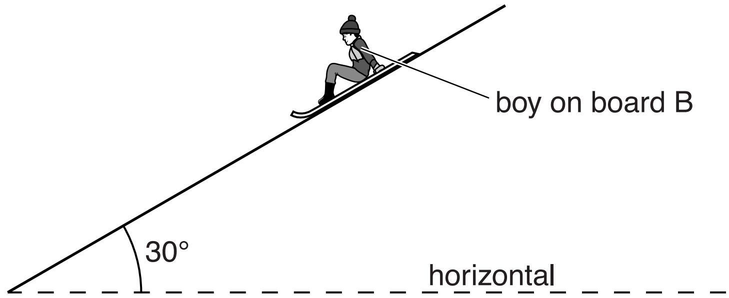


Fig. 5.1.

The angle of the slope to the horizontal is 30°. The total resistive force F acting on B is constant.

The boy and the board B has a total mass of 75 kg and moves with velocity v down the slope. The variation with time t of v is shown in Fig. 5.2.

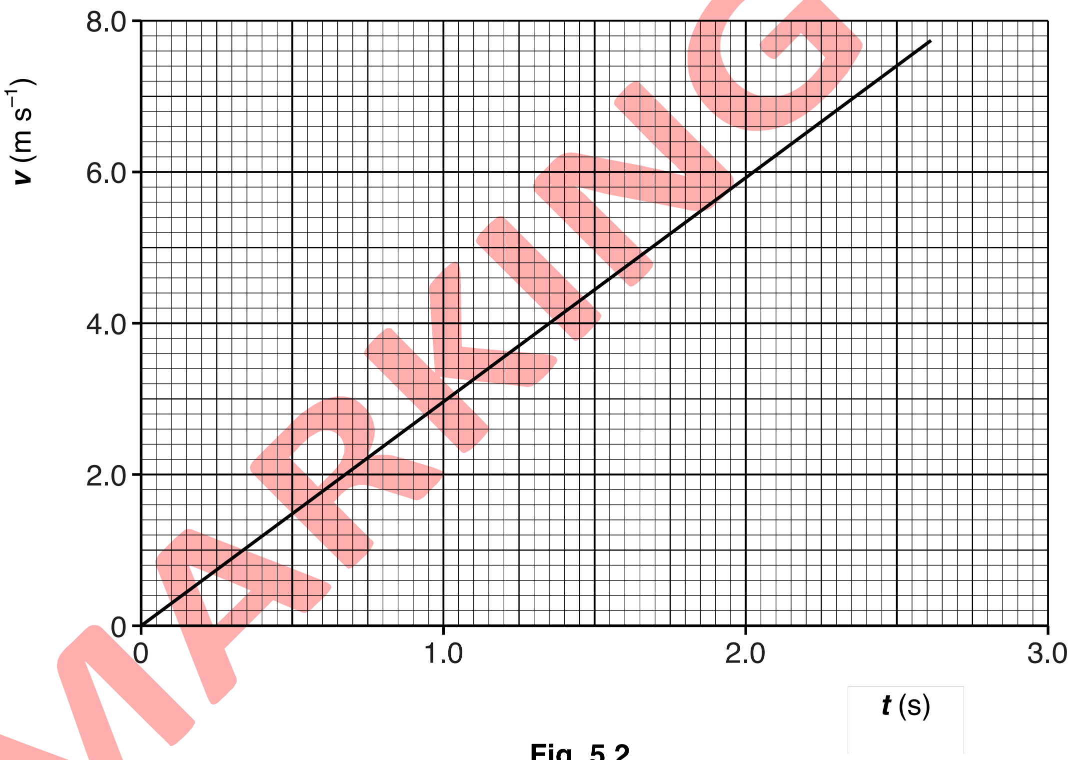


Fig. 5.2.

MARKING KEY

(a) For the boy and the board, from $t = 0$ to $t = 2.5$s, show that the distance moved down the slope is 9.3 m. (2 marks)

distance = area under line — C1

= (7.4 × 2.5) / 2 = 9.3 m (9.25 m) — M1 [2]

or

acceleration from graph $a = 7.4/2.5$ (= 2.96) — (C1)

and equation of motion $(7.4)^2 = 2 \times 2.96 \times s$ gives $s = 9.3$ (9.25) m — (A1)

(b) Calculate the gain in kinetic energy of the boy and board. (3 marks)

kinetic energy = $\frac{1}{2} m v^2$ — C1

$= \frac{1}{2} \times 75 \times (7.4)^2$ — C1

= 2100 J — A1

MARKING KEY

(c) calculate the loss in potential energy of the boy and board. (3 marks)

potential energy = mgh	C1	
$h = 9.3 \sin 30°$	C1	
PE = $75 \times 9.81 \times 9.3 \sin 30° = 3400$ J	A1	[3]

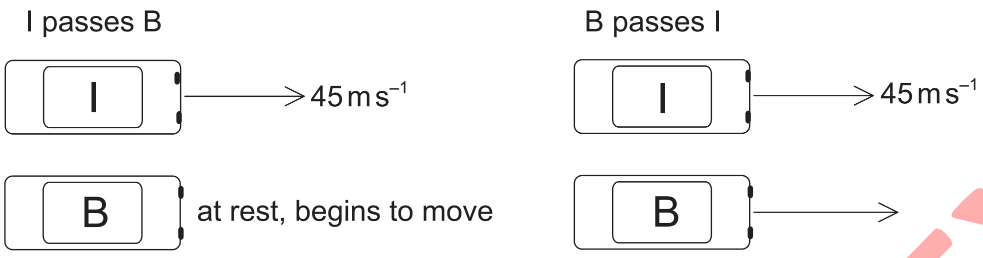
(d) calculate the resistive force *F*. (3 marks)

work done = energy loss	C1	
$R = (3421 - 2054) / 9.3$	C1	
$= 150\ (147)$ N	A1	[3]

MARKING KEY

Question 6 **(10 marks)**

Cars I and B are on a straight race track. I is moving at a constant speed of 45 m s^{-1} and B is initially at rest. As I passes B, B starts to move with an acceleration of 3.2 m s^{-2}.



At a later time, B passes I. You may assume that both cars are point particles.

(a) Show that the time taken for B to pass I is approximately 28 s. (4 marks)

distances itemized; *(meaning of numerical quantity must be clear)*
distances equated;
$t = \frac{2v}{a}$ / cancel and re-arrange;
substitution $\left(\frac{2 \times 45}{3.2}\right)$ shown / 28.1s seen; **[4]**

(b) Calculate the distance travelled by B in this time. (2 marks)

MARKING KEY

(c) A third car O with mass 930 kg joins the race. O collides with I from behind, moving along the same straight line as I. Before the collision the speed of I is 45 m s^{-1} and its mass is 850 kg. After the collision, I and O stick together and move in a straight line with an initial combined speed of 52 m s^{-1}.

Calculate the speed of O immediately before the collision. (2 marks)

$930 \times v + 850 \times 45 = 1780 \times 52$ ***or*** statement that momentum is conserved;
$v = 58\ \text{m s}^{-1}$; **[2]**

(d) The duration of the collision is 0.45 s. Determine the average force acting on O. (2 marks)

use of force $= \dfrac{\text{change of momentum}}{\text{time}}$ (or any variant, *eg*: $\dfrac{930 \times 6.4}{0.45}$);

$13.2 \times 10^3\ \text{N}$; *(must see matched units and value ie: 13 200 without unit gains MP2, 13.2 does not)* **[2]**

Allow use of 58 m s^{-1} from (c)(i) to give 12 400 N.

MARKING KEY