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.

Question 1 **(9 marks)**

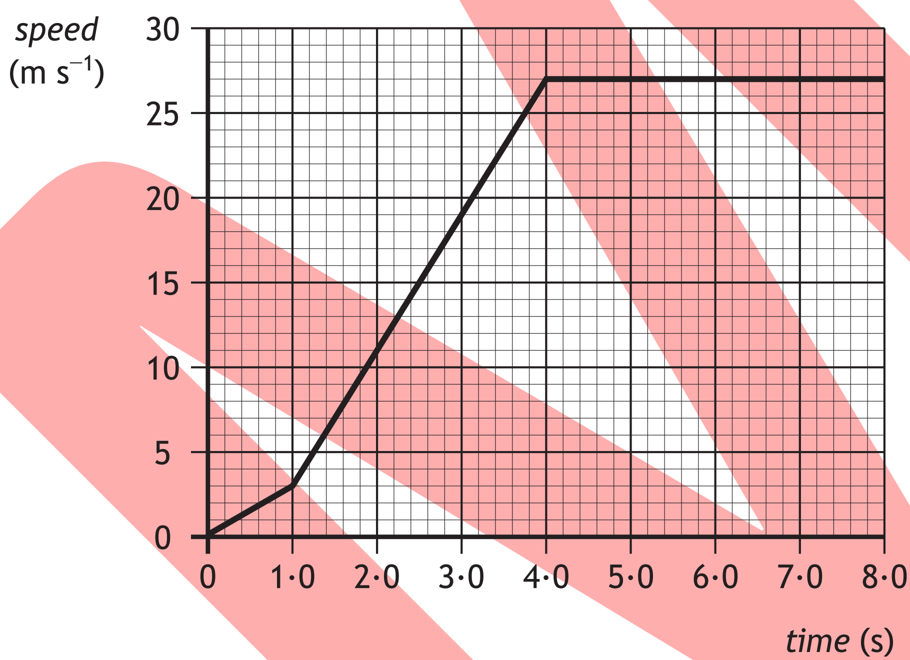
In speedway, motorbikes are raced anticlockwise round an oval track.

A race consists of four laps of a 380 m track.

(a) State the displacement of a motorbike from the start line to the finish line for a complete race. (1 mark)

0

(b) The speed-time graph of a motorbike for the first 8·0s of a race is shown.



(i) Calculate the distance travelled by the motorbike in the first 4·0 s of the race. (3 marks)

d = *area under graph* (1)

$= (0 \cdot 5 \times 1 \times 3)$

$+ (0 \cdot 5 \times 3 \times 24) + (3 \times 3)$ (1)

$= 46 \cdot 5 \text{ m}$ (1)

(ii) Determine the greatest acceleration of the motorbike during the first 8·0 s of the race. (3 marks)

$a = \frac{v - u}{t}$ (1)

$a = \frac{27 - 3}{3 \cdot 0}$ (1)

$a = 8 \text{ m s}^{-2}$ (1)

(iii) The winner of the race completes all four laps in a time of 79 s. Calculate the average speed of the winner. (3 marks)

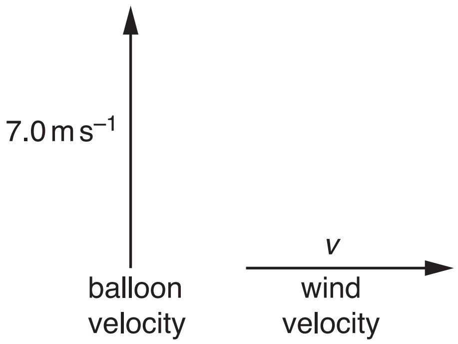
$d = \bar{v}t$ (1)

$4 \times 380 = \bar{v} \times 79$ (1)

$\bar{v} = 19 \text{ m s}^{-1}$ (1)

Question 2 **(9 marks)**

A hot air balloon rises with a vertical velocity of 7.0 m s^{-1}. A steady wind pushes the balloon with a horizontal velocity *v*. This is shown in the figure below.



The magnitude of the resultant velocity of the balloon is 8.8 m s^{-1}.

(a) On the figure above, draw an arrow labelled **R** to show the approximate direction of the resultant velocity of the balloon. (1 mark)

An arrow at an angle upwards and to the right

(b) State why the magnitude of the resultant velocity of the balloon is not the sum of the speeds of the balloon and the wind. (1 mark)

Velocity is a vector quantity / velocity (also) has direction

(c) With the help of a vector triangle, determine the magnitude of the wind velocity v and the angle θ between the resultant velocity of the balloon and the horizontal.

(4 marks)

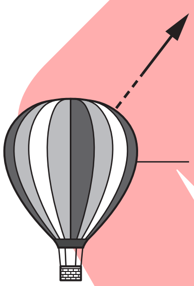
A suitable vector triangle with at least **two** vectors correctly labelled

$8.8^2 = 7.0^2 + v^2$ (Any subject)

$v = 5.3$ (m s^{-1})

$\theta = 53°$

(d) The figure below shows another balloon travelling with constant velocity 9.3 m s^{-1}.



Apart from the upthrust and the wind there are two other forces acting on the balloon. State these two forces.

Draw labelled arrows on the figure to indicate their approximate directions. State the direction of the resultant of these two forces.

(3 marks)

Weight acts vertically down

Drag / air resistance is opposite to the direction of the velocity (9.3 m s^{-1})

The resultant of the two forces is downward and to the left <u>and</u> at a greater angle to the horizontal (or steeper) than the velocity (9.3 m s^{-1}) vector / between drag and weight

Question 3 **(6 marks)**

A tennis ball is thrown vertically downwards and bounces on the ground. The ball leaves the hand with an initial speed of 1.50 m s^{-1} at a height of 0.650 m above the ground. The ball rebounds and is caught when travelling upwards with a speed of 1.00 m s^{-1}. Assume that air resistance is negligible.

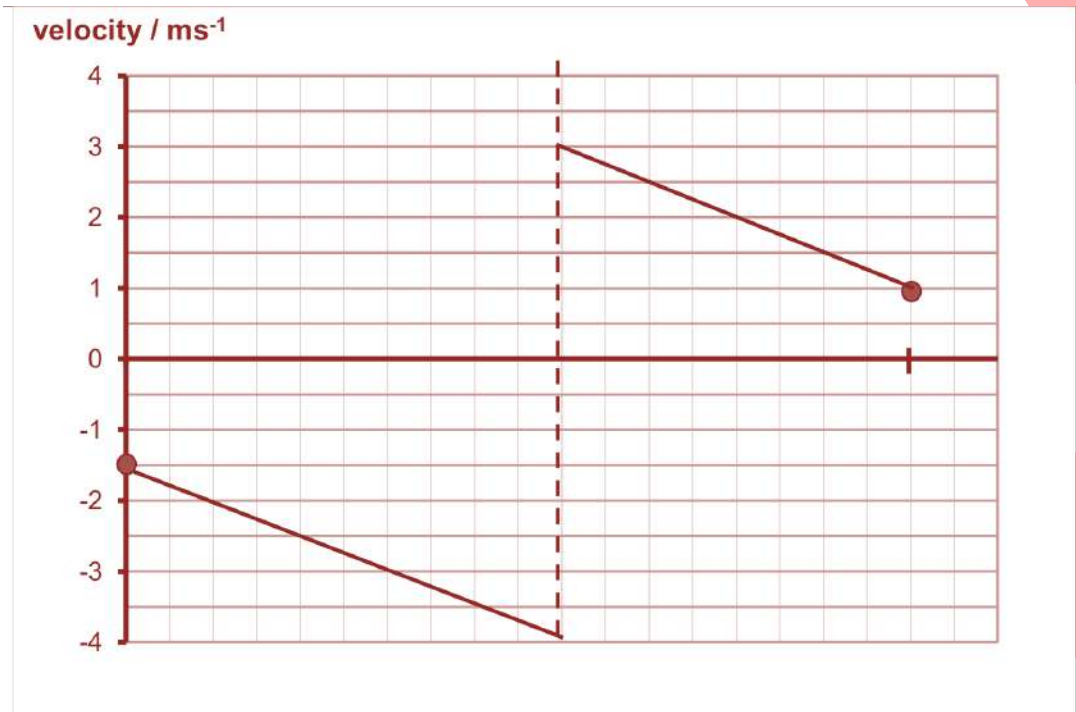
(a) Show that the speed of the ball is about 4 m s^{-1} just before it strikes the ground.
(3 marks)

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

$v = \sqrt{u^2 + 2as}$ ✓ $v = \sqrt{1.5^2 + 2 \times 9.81 \times 0.65}$ ✓

= (-)3.9 (m s^{-1}) ✓two or more sig fig needed (- 3.87337 m s^{-1})

(b) The ball is released at time t = 0. It hits the ground at time t_A and is caught at time t_B. On the figure below, sketch a velocity–time graph for the vertical motion of the tennis ball from when it leaves the hand to when it returns. The initial velocity **X** and final velocity **Y** are marked on the figure.
(3 marks)

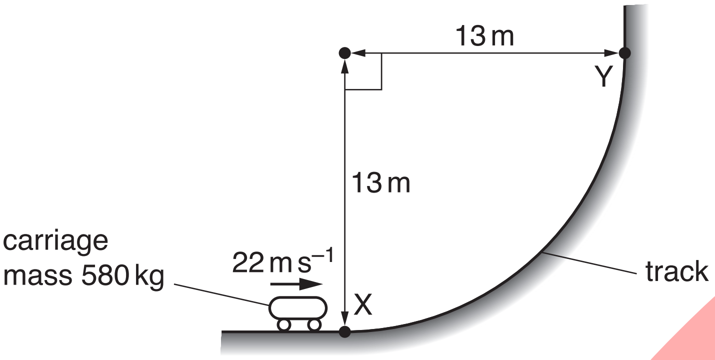


first line descends from X to the dotted line at t_A or up to one division sooner ✓ (allow line to curve)

first line is straight and descends from X to v = -4 (m s^{-1}) ✓(allow tolerance one division)
second line has same gradient as the first , straight and descends to v = 1(m s^{-1}) ✓ (tolerance ½ division)
A steep line may join the two straight lines but its width must be less than 2 divisions

Question 4 **(11 marks)**

A leisure-park ride consists of a carriage that moves along a railed track. Part of the track lies in a vertical plane and follows an arc XY of a circle of radius 13.0 m, as shown in the figure below.



The mass of the carriage is 580 kg. At point X, the carriage has velocity 22.0 m s^{-1} in a horizontal direction. The velocity of the carriage then decreases to 12.0 m s^{-1} in a vertical direction at point Y.

(a) For the carriage moving from X to Y;

(i) Show that the decrease in kinetic energy is 9.9×10^4 J. (2 marks)

1 $E = ½mv^2$

$(\Delta)E = ½ \times 580 \times (22^2 - 12^2) = 9.9 \times 10^4$ J

(ii) calculate the gain in gravitational potential energy. (2 marks)

2 $(\Delta)E = mg(\Delta)h$

$\Delta E = 580 \times 9.81 \times 13$

$= 7.4 \times 10^4$ J

See next page

(b) Show that the length of the track from X to Y is 20 m. (1 mark)

length = $(2\pi\times13)/4$ or $(\pi\times26)/4$ or $(\pi\times13)/2 = 20$ m

(c) Use your answers in (a) and (b) to calculate the average resistive force acting on the carriage as it moves from X to Y. (2 marks)

work done against resistive force = $9.9 \times 10^4 - 7.4 \times 10^4$
average resistive force = $(9.9 \times 10^4 - 7.4 \times 10^4)/20$

= 1300 N

(d) Describe the change in the direction of the linear momentum of the carriage as it moves from X to Y. (1 mark)

from horizontal/right to vertical / up or 90°

(e) Determine the magnitude of the change in linear momentum when the carriage moves from X to Y. (3 marks)

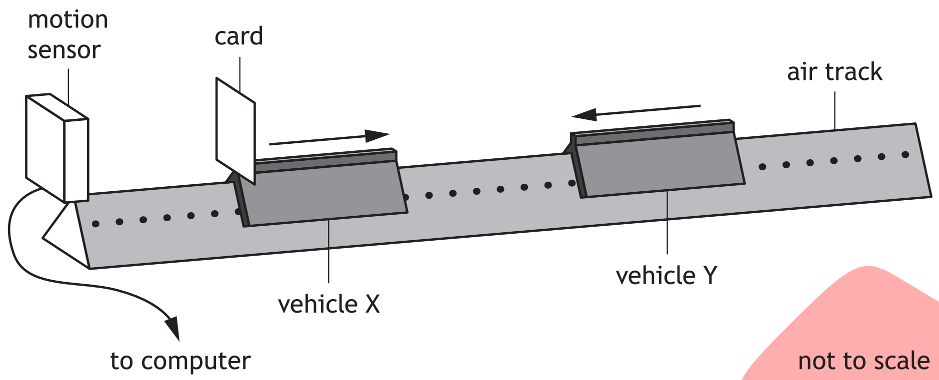
$p = mv$ or (580×22) or (580×12)

$\Delta p = [(580\times12)^2 + (580\times22)^2]^{0.5}$

$= 1.5 \times 10^4$ N s

Question 5 **(7 marks)**

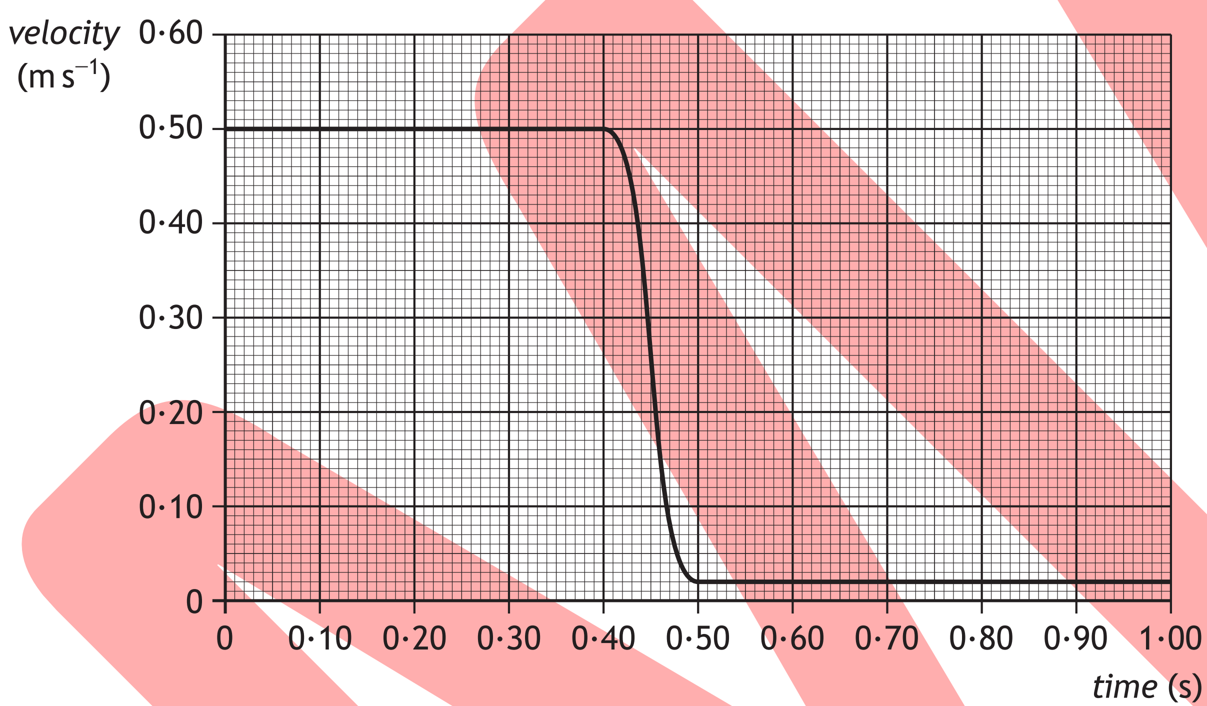
A student sets up an experiment to investigate a collision between two vehicles on a frictionless air track.



Vehicle Y of mass 0·50 kg is travelling to the left along the track with a speed of 0·30 m s–1.

The vehicles collide and move off separately.

A computer displays a graph showing the velocity of vehicle X from just before the collision to just after the collision.



(a) Show that the velocity of vehicle Y after the collision is 0·42 m s⁻¹. (2 marks)

(Total momentum before = Total momentum after)

$p = mv$

OR **(1)**

$(m_x u_x + m_y u_y) = (m_x v_x + m_y v_y)$

$(0 \cdot 75 \times 0 \cdot 50) + (0 \cdot 50 \times -0 \cdot 30) = (0 \cdot 75 \times 0 \cdot 02) + (0 \cdot 50 v_y)$ **(1)**

$v_y = 0 \cdot 42 \text{ m s}^{-1}$

(b) Determine the impulse on vehicle Y during the collision. (3 marks)

$Ft = mv - mu$ **(1)**

$Ft = (0 \cdot 50 \times 0 \cdot 42) - (0 \cdot 50 \times -0 \cdot 30)$ **(1)**

$Ft = 0 \cdot 36 \text{ N s}$ **(1)**

(c) Explain how the student would determine whether the collision was elastic or inelastic.
(2 marks)

Calculate the total kinetic energy before and (total kinetic energy) after. **(1)**

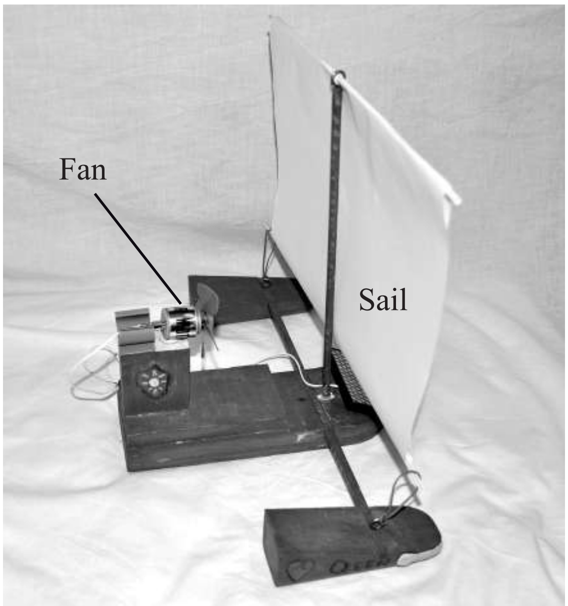
If E_k before is equal to E_k after the collision, is elastic.

OR

If E_k before is greater than E_k after, the collision is inelastic. **(1)**

Question 6 **(7 marks)**

The photograph shows a solar-powered model boat built by some technology students.

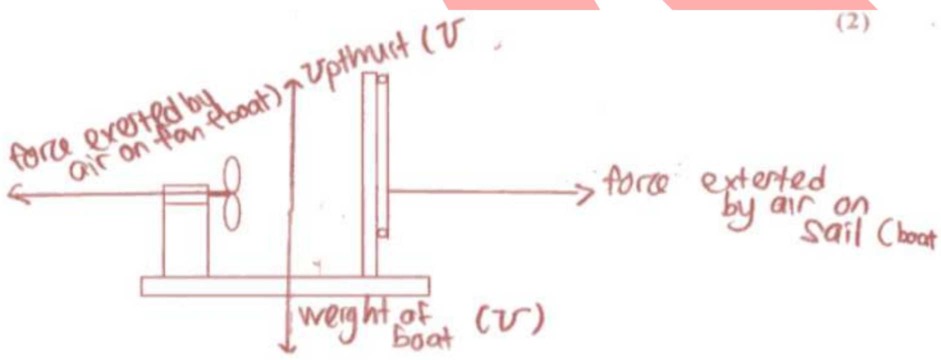


This boat has a solar-powered fan attached. The fan blows air towards the sail.

The technology students explain to a physics student that the fan exerts a force on the air and the air then exerts an equal force on the sail to drive the boat forwards. Assume that these two forces are equal for the rest of the question.
The physics student tells them that according to Newton's laws of motion this will not work.

(a) The boat is placed in the water and the fan switched on. The boat remains at rest.

Add labelled arrows to the diagram below to show the four forces acting on the boat in this situation. (2 marks)



(b) Use Newton's laws of motion to explain why the boat does not move horizontally. (3 marks)

Force from air on sail and force from air on fan equal and opposite	(1)
(so) resultant force zero	(1)
(N1 or N2/F=ma →) zero resultant force → no acceleration/doesn't start moving	(1)

no reference to Newton's 1st or 2nd law → max 2 marks

~~According to Newton's first~~, IN this case the force exerted by the air on the sail is at the opposite direction of the force exerted by the air on the fan, ~~therefore~~ these 2 forces are equal and opposite in direction, hence the resultant force at the ~~vertical~~ horizontal direction is 0. $\Sigma F = 0$ therefore the boat stays at rest according to Newton's first Law of motion.

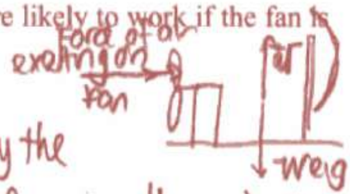
(c) The physics student suggests that the boat is more likely to work if the fan is reversed to point in the opposite direction. (2 marks)

Max 2

- Reverse fan → force/push on air away from boat / backwards / not towards sail (1)
- Force from air on fan forwards (1)
- There is a resultant force and the boat starts moving / accelerates (1)

(b) The physics student suggests that the boat is more likely to work if the fan is reversed to point in the opposite direction.

Explain this suggestion.



New diagram of forces not acting on the sail

(2)

If that is the case the force exerted by the ~~of the~~ fan on the air is reversed, and the air will ~~exerted~~ exert and equal and opposite force on the fan (boat) cause no other resistive forces hence the resultant force forward is not zero ∴ $\Sigma F > 0$ $\Sigma F = ma$, hence the boat will move with a ~~constant~~ acceleration.