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90255

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TAEA

Level 2 Physics, 2003

90255 Demonstrate understanding of mechanics

Credits: Six
2.00 pm Thursday 20 November 2003

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should answer ALL the questions in this booklet.

For all 'describe' or 'explain' questions, the answers should be written or drawn clearly with all logic fully explained.

For all numerical answers, full working must be shown and the answer must be rounded to the correct number of significant figures and given with an SI unit.

Formulae that you may find useful are given on page 2.

If you need more space for any answer, use the page provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–12 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

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Achievement Criteria		
Achievement	**Achievement with Merit**	**Achievement with Excellence**
Identify or describe aspects of phenomena, concepts or principles.	Give descriptions or explanations in terms of phenomena, concepts, principles and/or relationships.	Give concise explanations, that show clear understanding, in terms of phenomena, concepts, principles and/or relationships.
Solve straightforward problems.	Solve problems.	Solve complex problems.
Overall Level of Performance (all criteria within a column are met)		

You may find the following formulae useful.

$v = \frac{\Delta d}{\Delta t}$ $\qquad$ $a = \frac{\Delta v}{\Delta t}$

$v_f = v_i + at$ $\qquad$ $d = v_i t + \frac{1}{2}at^2$

$d = \frac{v_i + v_f}{2}t$ $\qquad$ $v_f^2 = v_i^2 + 2ad$

$a_c = \frac{v^2}{r}$

$F = ma$ $\qquad$ $\tau = Fd$

$F = -kx$ $\qquad$ $F_c = \frac{mv^2}{r}$

$p = mv$ $\qquad$ $\Delta p = F\Delta t$

$E_p = \frac{1}{2}kx^2$ $\qquad$ $E_k = \frac{1}{2}mv^2$ $\qquad$ $\Delta E_p = mg\Delta h$

$W = Fd$ $\qquad$ $P = \frac{W}{t}$

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You are advised to spend 60 minutes answering the questions in this booklet.

QUESTION ONE: Practice Run

Andrew is racing a car at the speedway. He drives the car in a clockwise direction, as shown in the diagram below. The length of the track is **790 m**.

(a) During a practice run, Andrew takes **25 seconds** to complete one lap.

Calculate the average speed of the car.

Average speed = ______________

(b) The car is moving along a straight section of the track at a speed of **26 m s^{-1}**.
The combined mass of Andrew and his car is **1200 kg**.

Calculate the kinetic energy of Andrew and his car.

Kinetic energy = ______________

Andrew now accelerates the car at **1.2 m s^{-2}** for **7.2 seconds**.

(c) Calculate the speed of the car at the end of this **7.2 second** period.

Speed = ____________

(d) Calculate the distance that the car travels during this **7.2 second** period.

Distance = ____________

Towards the end of the practice run, the car is moving along a straight section at a constant speed of **12 m s^{-1}** for **8.0 seconds**. The driving force required to keep the car moving at this constant speed is **400 N**.

(e) Calculate the power produced by the engine to keep the car moving at this constant speed. Give a unit with your answer.

Power = ____________ (unit)

(f) Even though energy is being supplied to the car, the kinetic energy of the car is not increasing.

Explain what happens to the energy.

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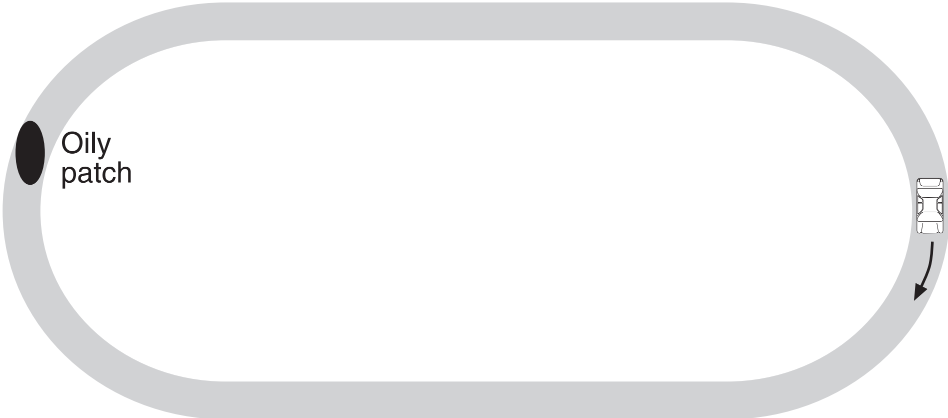
QUESTION TWO: Getting Around Corners

The curved ends of the track are semicircles of radius **56 m**. The car is now travelling along the semicircular part of the track at a constant speed as shown below. It takes **6.77 seconds** to complete one of the semicircular parts of the track. (The length of a semicircle is **πr**.)



(a) Show that the speed of the car is **26 m s^{-1}**.

(b) The combined mass of Andrew and the car is **1200 kg**.

Calculate the **size** of the force acting on the car at the position shown in the diagram above.

Force = ______________

(c) On the diagram above, draw an arrow to show the direction of the force acting on the car. Label this arrow 'F'.

(d) Explain why circular motion at a constant speed needs a force.

Andrew is now at the other end of the track, where he drives over a large slippery oily patch.

(e) Describe what you would expect to happen to the speed and the direction of the car.

(f) Explain why this happens to the speed and the direction of the car.

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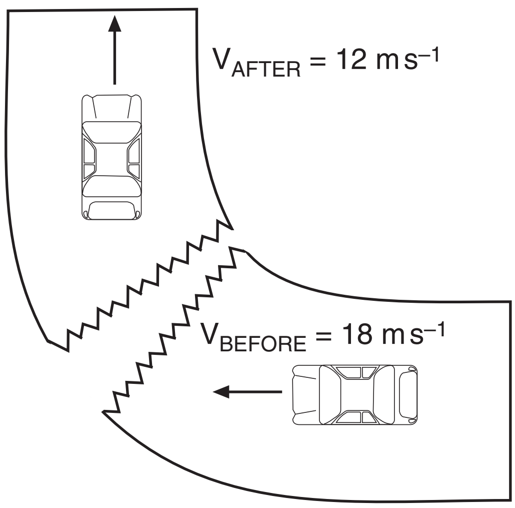
QUESTION THREE: Andrew's Mistake

When Andrew drives around a corner towards the end of the race, the car skids and collides into the safety barrier. Before the collision, the car was travelling left at **18 m s^{-1}**. After the collision, it was travelling at **12 m s^{-1}** at right angles to its original motion, as shown below.

(a) On the grid below, and using the scale provided, draw vectors to show:

(i) the velocity of the car **before** the collision

(ii) the velocity of the car **after** the collision.



Scale: 1 square = 2 m s^{-1}

(b) On the grid below, draw a vector diagram to show the change in velocity of the car.

Scale: 1 square = 2 m s^{-1}

Use your vector diagram to calculate the size and the direction (measured from the final velocity vector) of the change in velocity of the car.

(i) Speed = ______________________________

____

(ii) Direction = ______________________________

____

A few moments after the collision, the car is towed away by a tractor, as shown in the diagram below.

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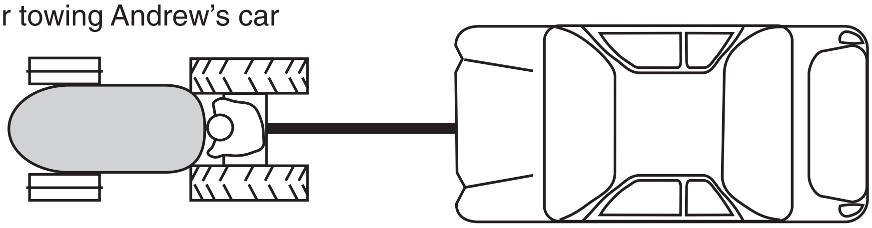
Tractor towing Andrew's car



Andrew's car

(c) Draw arrows on the diagram to show the horizontal forces acting on the car as it is being towed away. Label the forces.

(d) When the tractor begins to pull the car, the tow rope stretches. The spring constant of the tow rope is **29 500 N m^{-1}**. The tow rope stretches **0.085 m** when the car begins to move.

Calculate the force needed to start moving the car.
Give your answer to the correct number of significant figures.

Force = ____________________

(e) On one occasion, the tractor pulls the car with a force of **1650 N** and the car accelerates at a constant rate of **1.1 m s^{-2}** for a distance of **36 m**. (The combined mass of Andrew and the car is **1200 kg**.)

Calculate the work done against the friction.

Work = ____________________

QUESTION FOUR: Collision

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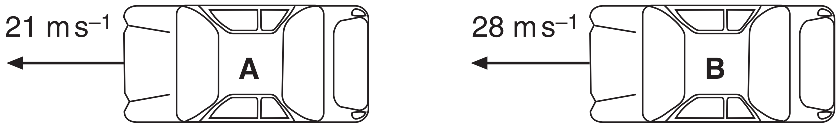
During a later race, two cars travelling in the same direction collide. The diagram below shows the positions of the cars before the collision. Car **B** has a mass of **1200 kg** and is travelling at **28 m s^{-1}**.



(a) Show that the momentum of car **B** before the collision is **33 600 kg m s^{-1}**.

(b) Car **A** has a mass of **1400 kg** and is travelling at **21 m s^{-1}**.

Calculate the **size** of the total momentum of the cars before the collision.

Momentum = ______________

Car **B** collides into the back of car **A**. After the collision, both cars are still travelling in the same direction. The momentum of car **B** after the collision is **26 000 kg m s^{-1}**.

(c) Calculate the velocity of car **B** just after the collision.

Velocity = ______________

(d) Explain why the total momentum of the cars remains constant during the collision.

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(e) Calculate the size of the change in momentum of car **B** and state its direction.

Size =

Direction =

(f) The cars were in contact for **1.3 seconds**. Calculate the average force during the collision.

Average force =

Extra paper for continuation of answers if required.
Clearly number the question.

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Question Number