



# ATAR PHYSICS

## UNIT 1 MOTION AND FORCES

### TEST 2 2021

Student Name:

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Teacher:           JRM           PCW           CJO  
(Please circle)

#### Time allowed for this paper

Working time for paper: 50 minutes.

#### Instructions to candidates:

- You must include **all** working to be awarded full marks for a question.
- Answers should be expressed to 3 significant figures unless otherwise indicated.
- Marks may be deducted if diagrams are not drawn neatly with a ruler and to scale (if specified).
- Marks will be deducted for incorrect or absent units.
- **No** graphics calculators are permitted – scientific calculators only.

Mark:	/ 51
=	%

**Question 1**

**(6 marks)**

A car of mass 1250 kg is travelling along the freeway at a velocity of 95.0 km h<sup>-1</sup> South. The driver spots a hazard ahead and applies a steady braking force over 85.0 m, bringing the car to rest.

- (a) Using the concepts of work and energy, calculate the average force required to bring the car to rest.

(4 marks)

- (b) Explain what would happen to the impulse if the driver applied a smaller braking force to bring the car to rest.

(2 marks)

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**Question 2****(2 marks)**

In the table below, state which of Newton's Laws applies **predominantly** in the scenario stated.

Scenario	Newton's Law
Getting thick liquids like tomato sauce out of a bottle can be difficult. Two methods work to solve the problem. You can bang the bottom of the upturned bottle <b>or</b> you can give it a sharp jerk downward.	
After kicking a football outside with his mate without shoes on, Jack notices that his foot has become pink and painful.	
Kim is pleased that next year at the Inters Athletics carnival he will still be using the same mass shot for the shot-put event. He plans on training hard over the year so he will be stronger and will be able to accelerate the put by a larger amount and hence, throw it further.	
Jack entered the train carriage to get to school one morning and stood by the door as all of the seats were taken. He was so preoccupied with his phone that he did not notice the train begin to accelerate, and promptly fell over.	

**Question 3****(7 marks)**

A lift of mass 455 kg is designed to reach its top speed of  $3.50 \text{ m s}^{-1}$  at a uniform rate in 2.00 seconds and to carry no more than 10 people at a time.

- (a) If the average mass of a person is taken to be 75.0 kg, calculate the magnitude of the tension (force) on the cable when the lift is fully loaded and stationary.

**(3 marks)**

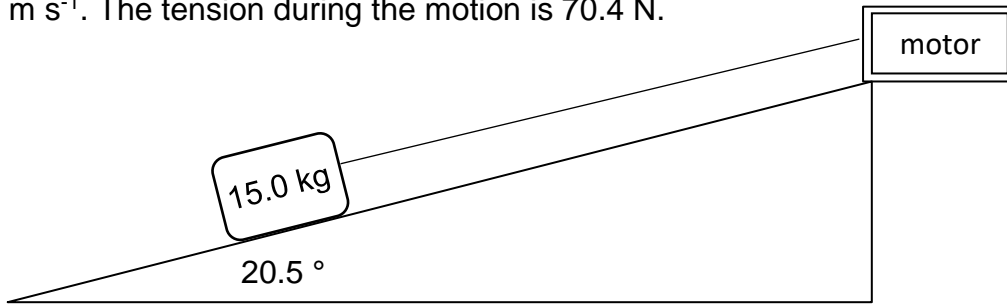
- (b) Calculate the maximum magnitude of tension that the cable experiences when accelerating the lift upwards.

**(4 marks)**

**Question 4**

**(13 marks)**

An electric motor is dragging a 15.0 kg mass up an incline of  $20.5^\circ$  at a constant speed of  $0.500 \text{ m s}^{-1}$ . The tension during the motion is 70.4 N.



- (a) In the space below, draw a vector diagram and a free body diagram of the forces acting on the mass while it is being dragged up the incline. (2 marks)

Vector Diagram	Free body diagram

- (b) Calculate the normal force and the frictional force acting on the mass while it is being dragged up the incline. (4 marks)

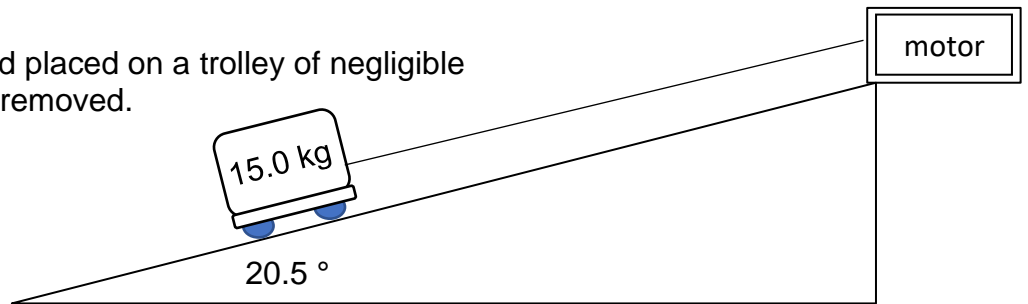
$F_N =$  \_\_\_\_\_

$F_F =$  \_\_\_\_\_

- (c) Show via calculation that power output of the motor while the mass is being raised is 35.2 W.

(3 marks)

Suppose the mass was instead placed on a trolley of negligible mass such that friction is now removed.



- (d) Calculate the rate that the **vertical height** changes providing the power output remains constant.

(4 marks)

**Question 6**

**(12 marks)**

SoftStop® is a safety barrier designed to reduce the injuries suffered by drivers who are unfortunate enough to experience a head on collision with the end of the barrier. The vertical metal piece (with the black and yellow signage) is attached to anchor points in the ground but are designed to travel back along the length of the barrier to reduce the injuries that drivers would receive in a collision.



Figure 1: SoftStop® Barrier



Figure 2: After a collision

A deceleration of 40.0 g's ( $392 \text{ m s}^{-2}$ ) provided by a collision with a rigid barrier would cause serious internal injury while a SoftStop® collision can reduce the impact to 20.0 g's; resulting in far less chance of significant injuries.

- (a) Explain how the SoftStop® is able to reduce the injuries experienced by drivers in a collision.

**(3 marks)**

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Consider a 65.0 kg occupant initially travelling at  $15.0 \text{ m s}^{-1}$  East who is brought to rest by a SoftStop® barrier.

- (b) Calculate the impulse of the occupant involved in a collision with a SoftStop® barrier.

**(3 marks)**

(c) Calculate the maximum time taken for the occupant to come to rest with the two possible decelerations provided. (2 marks)

(d) Hence, calculate the average Force exerted on the occupant. (2 marks)

The graph below shows the Force-time curve for a collision with a rigid barrier.

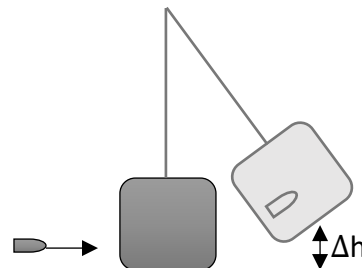
(e) On the graph below, sketch a Force-time graph of a collision with a SoftStop® Barrier. (2 marks)



**Question 5****(11 marks)**

A 0.0500 kg bullet is fired at a speed of  $145 \text{ m s}^{-1}$  and is embedded into a stationary ballistics block of mass 2.20 kg (an example of a coupled collision).

- (a) Using concepts of conservation of momentum, calculate the combined speed of the ballistics block (with bullet embedded).

**(3 marks)**

- (b) Show via calculation that the collision above is an inelastic one and determine how much energy was converted to heat and sound. (If you could not complete (a), use  $v = 6.00 \text{ m s}^{-1}$ )

**(3 marks)**

In a separate experiment a different 0.0600 kg bullet was fired at another similar stationary ballistics block of the same mass and it was observed to rise to a maximum vertical height of 0.430 m.

- (c) Calculate, using concepts of conservation of energy and momentum, the initial speed of the bullet.

**(5 marks)****END OF TEST**