PHYSICS VCE UNITS 3&4
DIAGNOSTIC TOPIC TESTS 2017

TEST 5: HOW FAST CAN THINGS GO? (II)

TOTAL 45 MARKS (45 MINUTES)

Student's Name: ____________________________ Teacher's Name: ____________________________

Directions to students

Write your name and your teacher's name in the spaces provided above.
Answer all questions in the spaces provided.

Use $g = 10$ N kg^{-1}.

Question 1 (23 marks)

Two dodgem cars are moving toward each other as shown in Figure 1.

dodgem car 1 (300 kg)
initial speed = 2.4 m s^{-1}

dodgem car 2 (250 kg)
initial speed = 1.8 m s^{-1}

Figure 1

The dodgems collide and dodgem car 1 bounces back from its initial direction (to the left in the diagram) of motion at 1.0 m s^{-1}.

a. Determine the total momentum of the two dodgem cars before the collision (magnitude and direction). 3 marks

Ns	left right

b. The total momentum of the dodgem cars is conserved.

Explain what this means and the assumption that exists when it is true. 2 marks

c. Determine the velocity of dodgem car 2 after the collision (magnitude and direction). 3 marks

$m\ s^{-1}$	left right

d. Determine the impulse experienced by dodgem car 1. 2 marks

Ns

e. Determine the average force experienced by dodgem car 1 if the collision time was 0.100 seconds. 2 marks

N

f. If instead the dodgem cars couple and move off together, determine their speed and direction, circling one of left or right. 3 marks

$m\ s^{-1}$	left right

The dodgem cars again move toward each other at the same velocities for a second time. The velocities before and after the collision are given in the table below.

	Dodgem car 1	**Dodgem car 2**
Velocities before collision	$2.0\ m\ s^{-1}$ right	$2.0\ m\ s^{-1}$ left
Velocities after collision	$1.0\ m\ s^{-1}$ left	$1.6\ m\ s^{-1}$ right

g. Determine whether or not the collision is elastic or inelastic by providing calculations for this. Working must be shown. Explain any differences that you find in your calculations. 4 marks

h. The dodgem cars have a bumper to reduce the impact when they collide.

Explain, using physics principles, how the bumper reduces the impact during collisions in comparison to vehicles that have no bumper. 4 marks

Question 2 (5 marks)

A tow truck applies a horizontal force of 3000 N on a 1000 kg car for a period of three seconds over a distance of 10 m. Figure 2 shows the tow truck towing a vehicle.

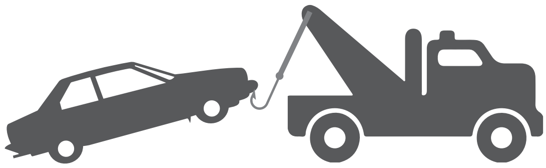

Figure 2

a. Calculate the work done by the tow truck over the 10 m distance. 2 marks

J

Figure 3 shows a graph of the force acting on a 500 kg satellite as a function of its distance from the Moon's centre.

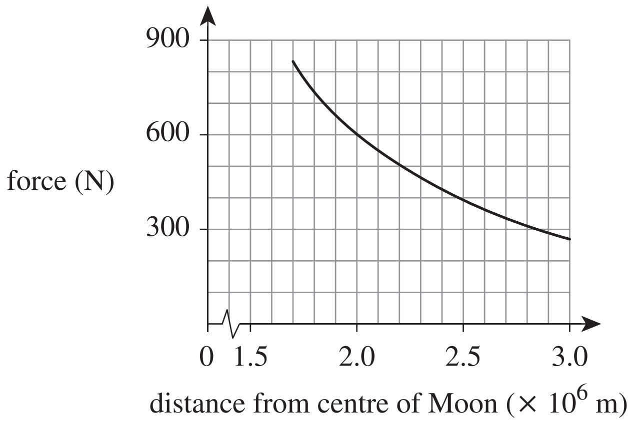

Figure 3

b. Determine the work done by the satellite engines to move the satellite from its 2200 km position to 2500 km from the centre of the Moon. 3 marks

J

Question 3 (3 marks)

A high jumper is running at 8.0 m s^{-1} at the point at which she jumps to clear the high jump bar. Her centre of mass is 1.0 m above ground when she jumps. Her centre of mass is 2.15 m above ground when she clears the bar. This is shown in Figure 4.

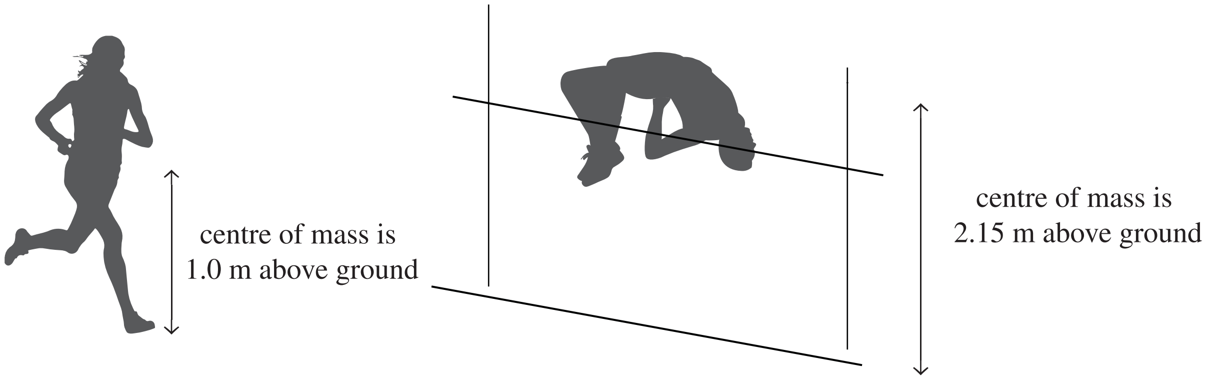

Figure 4

The mass of the high jumper is 65 kg.

Determine the speed of the high jumper at the height where she clears the bar. Ignore frictional forces.

m s^{-1}

Question 4 (14 marks)

A slingshot consists of a light leather cup containing a steel ball that is pulled back against a rubber band. It takes a force of 30 N to stretch the band by 10 cm. Such a slingshot is shown in Figure 5.

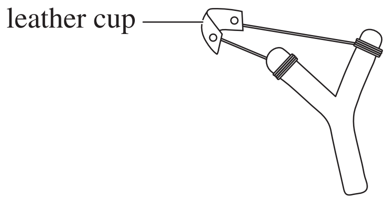

Figure 5

a. Show that the stiffness constant of the rubber band is 300 N m^{-1}. 2 marks

b. What is the average force needed to stretch the rubber band by 30 cm? 2 marks

N

c. Assuming that Hooke's law applies to the rubber band, what is the elastic potential energy stored in the band when it is stretched by 20 cm? 2 marks

J

d. What work is done by the hand that stretches the rubber band by 20 cm? 1 mark

J

A 30 g steel ball is placed in the leather cup of the slingshot. The leather cup is pulled back by 20 cm and fires the ball vertically into the air.

e. Calculate the release speed of the ball assuming that all of the energy stored in the rubber stretched by 20 cm is passed to the ball. 3 marks

$m\ s^{-1}$

f. What maximum height does the steel ball reach? 2 marks

m

g. In reality, the ball reaches a lesser height than the answer calculated in part **e.**
Explain why. 2 marks