Billanook College

July Exam 2016

VCE Physics

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 2 hour 30 minutes

Student's Name: Answers

Teacher's Name : ______________________

Structure of Booklet

Section	Number of Questions	Number of marks
Motion in One and Two Dimensions	8	47
Electronics and Photonics	17	50
Electric Power	10	53
Total		150

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, up to four pages (one A3 sheet, or two A4 sheets bound together) of pre-written notes (typed or handwritten), and one scientific calculator.
Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied:
Question and answer booklet
Two pages of formula/data.

Instructions
Write your name and teacher's name in the space provided above.
Always show your working.
All written responses should be in English

*** Please note: questions are not in order ***

Students are NOT permitted to bring mobile phones and/or any other electronic communications equipment into the examination room.

Area of study 1 – Motion in one and two dimensions

Question 1

A four wheel drive (4WD) of mass 1800 kg pulls a boat on a trailer at constant speed up a boat ramp with an incline of 18°. The combined mass of the boat and trailer is 700 kg.

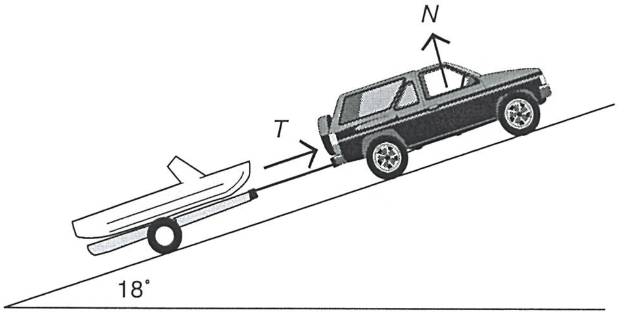


Figure 1

A frictional force of 300 N acts between the boat trailer and the ramp, and a frictional force of 850 N acts between the 4WD and the ramp.

a. Calculate the force exerted by the boat ramp on the four wheel drive, shown as *N* in Figure 1.

$F_N = 1800 \times 10 \times \cos 18$

17119	N

2 marks

b. Calculate the magnitude of the tension in the coupling joining the trailer and the four wheel drive, labelled *T* in Figure 1.

component of weight down slope and friction

$700 \times 10 \times \sin 18 + 300$

$= 2463$

2463	N

3 marks

c. Calculate the power developed by the four wheel drive if it moves the boat 15 metres up the ramp in 8.0 seconds.

$F_D = 850 + 300 + (1800 + 700) \times 10 \times \sin 18$

$= 8875$ N

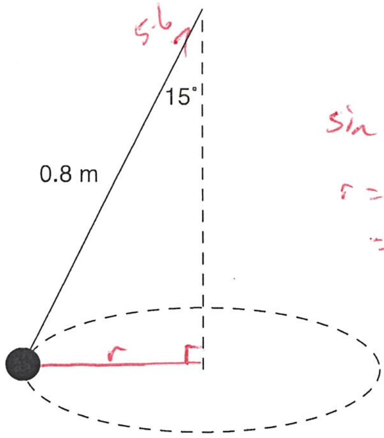
$P = \frac{W}{t} = \frac{Fx}{t} = \frac{8875 \times 15}{8} = 16641$

16641 W

3 marks 3

Question 2

Bella is investigating circular motion by swinging a pendulum constructed of a spherical mass on the end of a 0.8 m length of string, so that it moves in a circle, as shown in Figure 2. The tension in the string is 5.6 N.



$\sin 15 = \frac{r}{0.8}$

$r = 0.8 \sin 15$

$= 0.207$ m

Figure 2

The string makes an angle of 15° with the vertical and Bella measures the time for 10 rotations to be 17 seconds.

$T = 1.7$ s

a. Calculate the speed of the mass as it moves in circular motion.

$v = \frac{2\pi r}{T} = \frac{2\pi \times 0.207}{1.7} = \frac{1.30..}{1.7}$

$= 0.765$

0.77 m s^{-1}

3 marks 3

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b. Calculate the mass that is on the end of the string, and hence the centripetal force acting on the mass.

$T\cos 15 = mg$

$\frac{5.6 \cos 15}{10} = m = 0.54$

$F_c = \frac{mv^2}{r} = \frac{0.54 \times 0.77^2}{0.21} = 1.51$

$T \sin 15 = 1.45$

mass = 0.54 kg	centripetal force = 1.51 N

or 1.45

4 marks 4

c. If Bella was to increase the mass on the end of the string and rotate it at the same speed and angle, which of the following would occur?

A. The centripetal force would decrease and the tension in the string would increase.

B. The centripetal force would increase and the tension in the string would decrease.

C. The centripetal force would decrease and the tension in the string would decrease.

D. The centripetal force would increase and the tension in the string would increase.

D

2 marks 2

d. Bella now uses the same equipment (with the original mass calculated in Question 5) and swings it in a vertical circle, as shown in Figure 3.

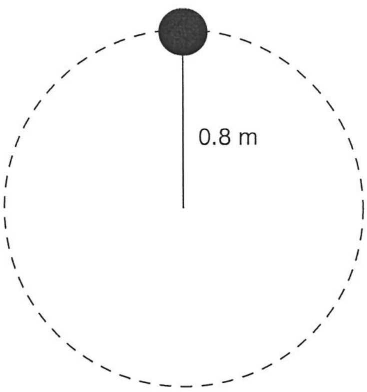

Figure 3

Calculate the minimum speed at which the mass can travel at the highest point of the circle to remain in circular motion.

$\frac{mv^2}{r} = mg$

$v^2 = rg$

$v = \sqrt{rg} = \sqrt{0.8 \times 10} = 2.8$

2.8 m s^{-1}

2 marks 2

Question 3

A new toy uses a spring to launch a small rubber ball, of mass 20 g, into the air so that it can land in a basket. The launch angle can be varied. To launch the ball, the spring is compressed and the ball placed on top of it. The arrangement is shown in Figure 4.

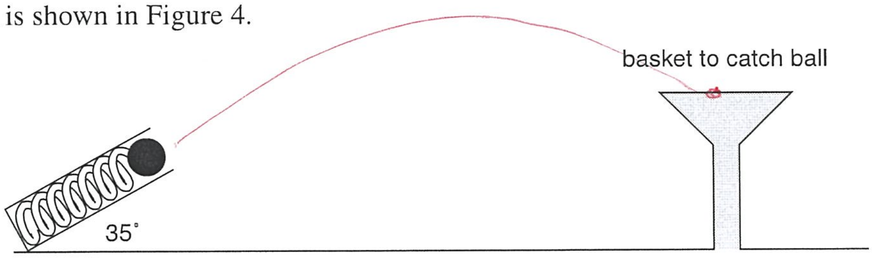

Figure 4

0.08 m 0.02 kg

When the spring is fully compressed by 8.0 cm the launch speed of the 20 g ball is 12.0 m s^{-1}. The launcher is set so that it makes an angle of 35° with the horizontal. When the launcher is set at this angle the top of the basket is 1.2 m higher than the top of the launcher. Ignore the effects of air resistance for Question 3.

a. Calculate the force constant for the spring in the launcher.

$E_p = E_k$

$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$

$\frac{1}{2} \times k \times 0.08^2 = \frac{1}{2} \times 0.02 \times 12^2$

$k = 450$

450 N m^{-1}

3 marks 3

b. Calculate the maximum height above the launcher reached by the ball if the launch angle is 35°.

$\frac{1}{2}mv^2 = mgh$

$\frac{1}{2} \times (144 \sin 35) = 10 \times h$

not vertical.

$\frac{1}{2}m(12 \sin 35)^2 = mgh$ $h = 2.3687$

or $v^2 = u^2 + 2ax$

$0 = (12 \sin 35)^2 + 2x - 10 \times x$

2.4 m

2 marks 2

c. If the launch angle is 35°, at what horizontal distance from the launch point should the basket be placed so that it will catch the ball **on its way down**?

$u = 12 \sin 35$
$a = -10$
$x = 1.2$
$v = ?$
$v^2 = u^2 + 2ax$
$v = \pm 4.8$
time of flight to -4.8
1.175

1.2 m

$12 \sin 35 = u$ $a = -10$
$x = 1.2$ $t = ?$

~~$x = ut + \frac{1}{2}at^2$~~
~~$1.2 = 12 \sin 35 t - 5t^2$~~
~~first time, $t = 1.066$~~

total time.
$0 = 12 \sin 35 - 5t^2$
1.17
$1.17 - 1.066 = 0.107$

11.5 m

4 marks

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Question 4

A dodgem car of mass 600 kg (including its occupants) is travelling at 5.0 m s^{-1} East when it collides with another dodgem car travelling at 2.0 m s^{-1} West.

Figure 5

Immediately after the collision the two dodgem cars are locked together and move East at 1.0 m s^{-1}.

a. Calculate the mass of the dodgem car which is initially moving West.

$p_{before} = p_{after}$

800 kg

2 marks

b. If the collision between the two dodgem cars takes 0.2 seconds, calculate the magnitude of the force exerted by the West moving car on the East moving car during the collision.

$\Sigma F \Delta t = m \Delta v$

12000 N

2 marks

c. Explain, in terms of energy and work done, why the force calculated in Question 12 would be greater if the dodgem cars had rigid metal bumper bars rather than bumper bars made of rubber.

The change in E_K is fixed ① If rigid, then x will be shorter ①.

$W = Fx$

↑ constant ↑ if x smaller, then F will be larger ①.

3 marks

Question 5

Mass of Mars	6.37×10^{23} kg
Radius of Mars	3.43×10^{6} m
Period of rotation of Mars	24.6 hrs
Period of Mars orbit around Sun	688 days

An artificial satellite is placed in an orbit around Mars so that it remains above the same point on the equator of Mars at all times (similar to a Geostationary orbit on Earth).

a. Calculate the orbit altitude (distance above the surface of Mars) required for the satellite to remain in this orbit.

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$\frac{r^3}{(24.6 \times 3600)^2} = \frac{6.67 \times 10^{-11} \times 6.37 \times 10^{23}}{4\pi^2}$$

$r = 20360741$

$- 3.43 \times 10^6 =$

~~2.0×10^7~~ m

1.7×10^7

3 marks 3

b. What is the apparent weight of the satellite when it is in this orbit? Explain your answer.

Apparent weight = 0 N

in 'freefall' so no normal.

2 marks

c. Calculate the gravitational field strength at the surface of Mars. You must show your working.

$$g = \frac{GM}{r^2} = \frac{6.67 \times 10^{-11} \times 6.37 \times 10^{23}}{(3.43 \times 10^6)^2}$$

$= 3.6$

3.6 N kg^{-1}

2 marks

END OF AREA OF STUDY 1

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A spring is used to propel a ball bearing over a rough carpet and up a small smooth slope as shown in Figure 5. Once the spring is compressed by 4 cm, the ball bearing of mass 100 g is placed on the spring. The spring is released and the ball moves with an initial velocity of 8 m s^{-1}.

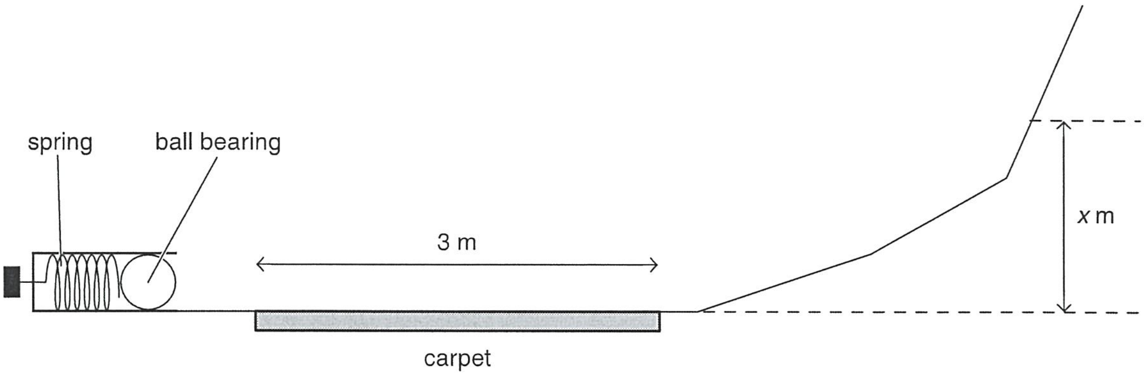

Figure 5

Question 7

Calculate the spring constant of the spring used to propel the ball bearing.

$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$

4000

~~1260~~ N m^{-1}

2 marks

The ball bearing moves across a rough carpet and hence it loses 2 J as heat.

Question 8

Calculate the average frictional force that acts on the ball bearing as it moves across the carpet.

$\Delta E = Fd$

0.67 N

2 marks

Question 9

Calculate the vertical height at which the ball bearing stops.

1.2 m

2 marks