

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

Letter

Figures

Words

VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY



**Victorian Certificate of Education
2001**

PHYSICS

Written examination 2

Tuesday 13 November 2001

Reading time: 9.00 am to 9.15 am (15 minutes)

Writing time: 9.15 am to 10.45 am (1 hour 30 minutes)

QUESTION AND ANSWER BOOK

Structure of book

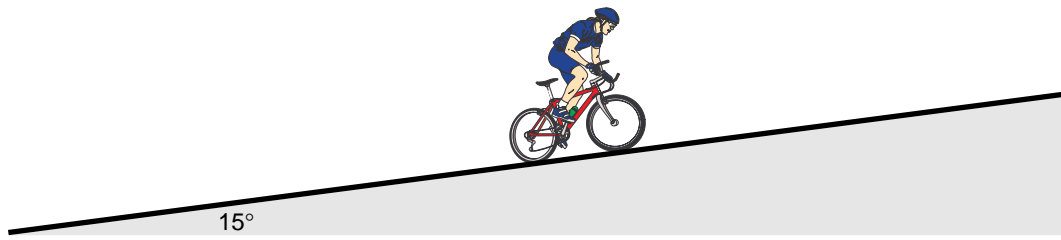
<i>Area</i>	<i>Number of questions</i>	<i>Number of questions to be answered</i>	<i>Number of marks</i>
1. Motion	15	15	36
2. Gravity	7	7	14
3. Structures and materials	9	9	24
4. Ideas about light and matter	7	7	16
			Total 90

Materials

- Question and answer book of 27 pages, with a detachable data sheet in the centrefold.
- An A4 sheet of notes which may be typed or handwritten on both sides.
- One approved graphics calculator (memory cleared) and/or one scientific calculator.

Instructions

- Detach the data sheet from the centre of this book during reading time.
- Write your **student number** in the space provided on this question and answer book.
- Answer all questions in the spaces provided.
- **Always** show your working where space is provided because marks may be awarded for this working.
- All written responses must be in English.

AREA 1 – Motion**Figure 1**

A cyclist pedals up a 15° slope at a constant speed as shown in Figure 1. The total mass of rider and bicycle is 100 kg.

Question 1

What is the magnitude of the **net** force on the bicycle and rider when travelling up the slope?

2 marks

Question 2

Calculate the magnitude of the normal reaction force acting on the bicycle when travelling up the slope.

$$(g = 9.8 \text{ m s}^{-2})$$

3 marks

Some time later the rider turns around and rolls at constant speed down the slope.

Question 3

Calculate the magnitude of the total frictional forces that are acting on the rider and bicycle while travelling down the slope.

2 marks

The average speed for the uphill part of the journey is 4 m s^{-1} , while the average speed for travelling the same distance for the downhill part of the journey is 8 m s^{-1} .

Question 4

Which of the speeds (**A–D**) is the average speed of the rider for the whole journey? You may ignore the time taken to turn around.

- A. 5.3 m s^{-1}
- B. 5.7 m s^{-1}
- C. 6.0 m s^{-1}
- D. 6.3 m s^{-1}

2 marks

Mountain bikes are often made with front and rear springs to provide a smoother ride.

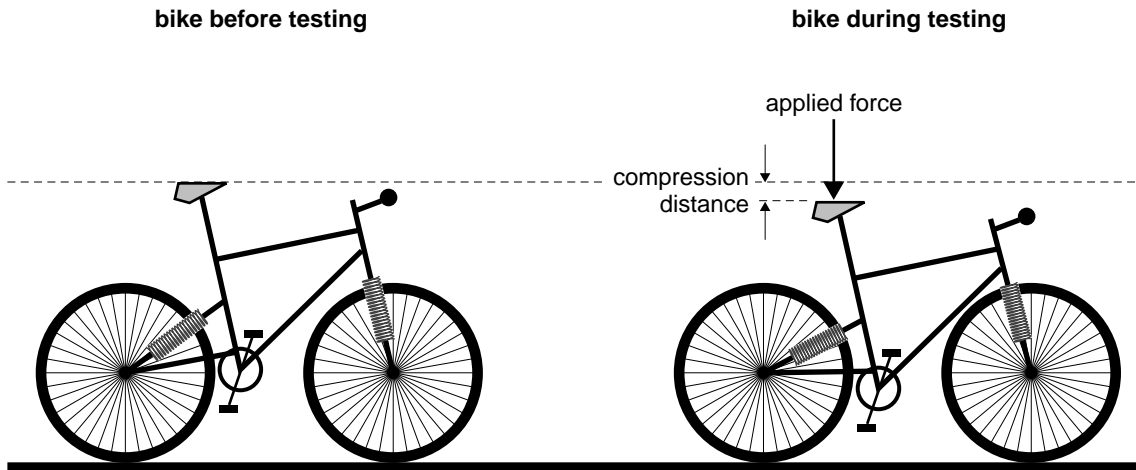


Figure 2

A manufacturer investigates the compression of a bike by pushing down on the seat as shown in Figure 2, and measuring how far the seat moves down as a result. The result of these investigations is given in the graph in Figure 3 below, showing the vertical force exerted on the seat versus compression distance.

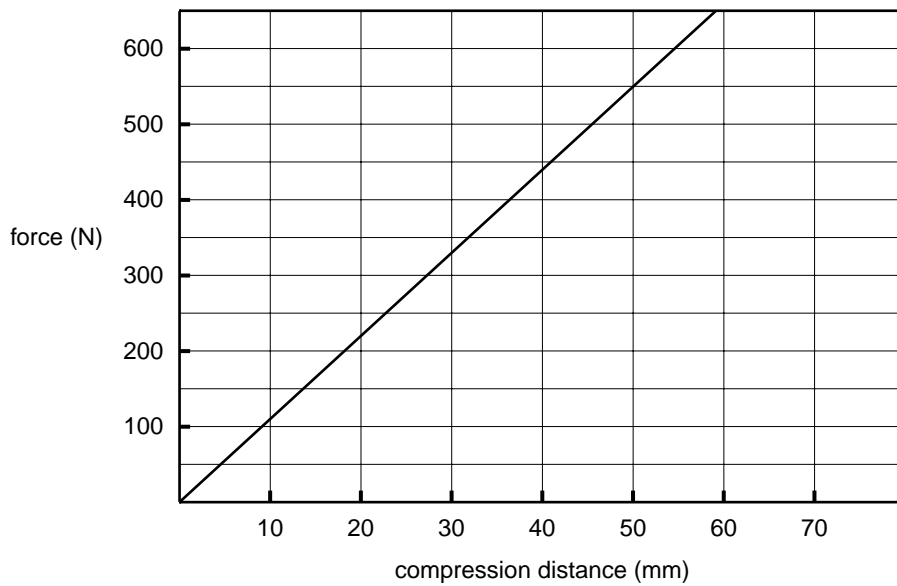


Figure 3

Question 5

Calculate the mass of a person who produces a compression distance of 50 mm when seated on this mountain bike.

$$(g = 9.8 \text{ N kg}^{-1})$$

2 marks

Question 6

Calculate the total potential energy stored in the springs when the person is seated on the mountain bike.

2 marks

Figure 4 shows a section of a roller coaster track, with a roller coaster car travelling at constant speed from the left.

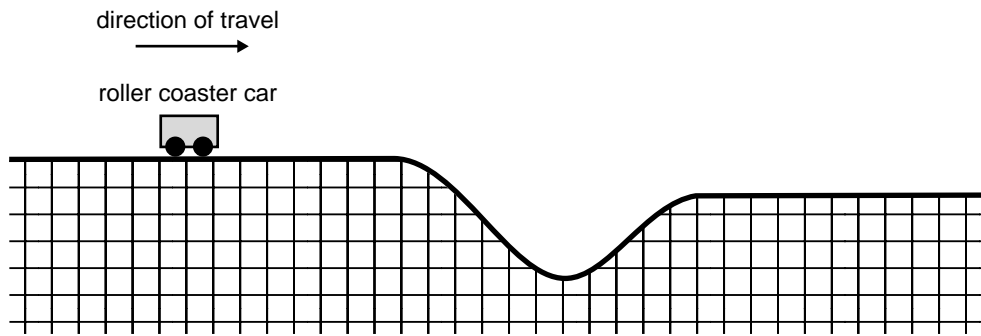
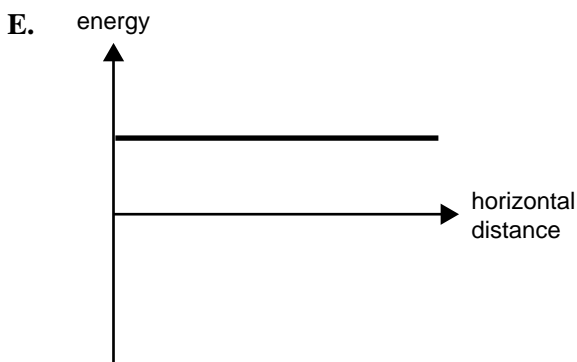
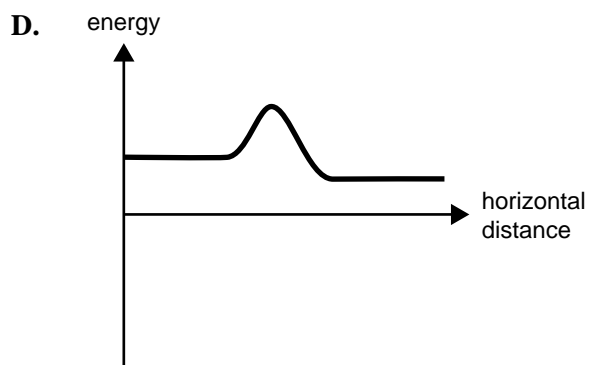
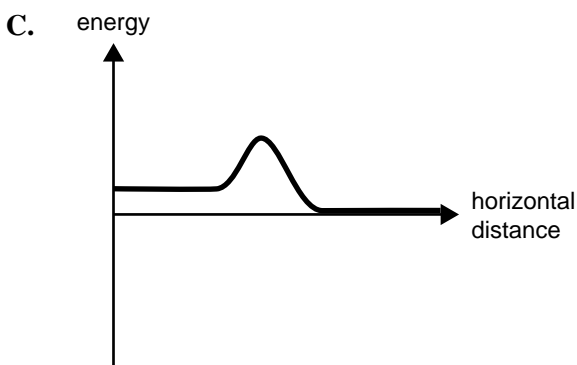
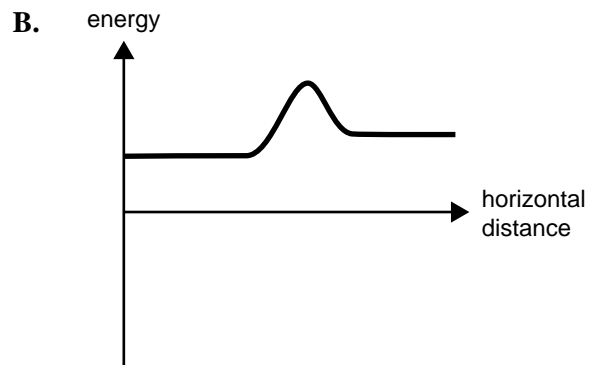
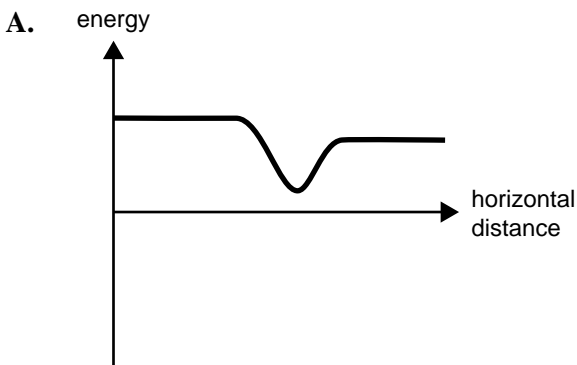


Figure 4

Use the following graphs (A–E) to answer Questions 7 to 9.



Question 7

Which of the graphs (A–E) best shows the gravitational potential energy of the roller coaster car against the horizontal distance from the start of the track?

2 marks

Question 8

Which of the graphs (A–E) best shows the kinetic energy of the roller coaster car against the horizontal distance from the start of the track? (Neglect frictional effects.)

2 marks

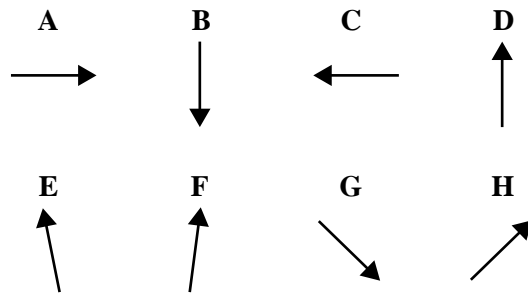
Question 9

Which of the graphs (A–E) best shows the total energy of the roller coaster car against the horizontal distance from the start of the track? (Neglect frictional effects.)

1 mark

Question 10

Which of the arrows (**A–H**) best indicates the direction of the net force on the roller coaster car at the lowest point, assuming that friction and air resistance **cannot** be neglected?



2 marks

A recent car advertisement states: 'you can legally floor the throttle for 5.9 seconds'. This means that it takes 5.9 s to reach a speed of 100 km h^{-1} starting from rest. Assume that this situation can be modelled as uniform acceleration.

Question 12

Calculate the magnitude of the uniform acceleration of this car and state the unit of this acceleration.

3 marks

Question 13

Calculate the distance travelled in this time of 5.9 seconds.

2 marks

At a car show a driver plans to drive up a 20° ramp and jump her car across a row of parked cars, as shown in Figure 6.

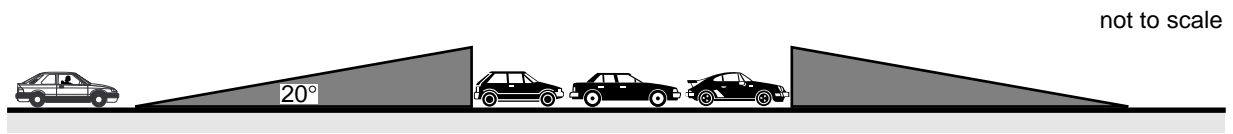


Figure 6

She plans to be travelling at 30 m s^{-1} at the instant the car leaves the ramp. The landing ramp on the opposite side of the gap is at the same height as the launching ramp.

Question 15

Calculate the maximum gap distance that the car can safely jump. (Model the car as a point object.)

$$(g = 9.8 \text{ m s}^{-2})$$

m

4 marks

AREA 2 – Gravity

The Mir space station orbited Earth at an **altitude** of 390 km. The total mass of the space station was 140 tonnes and Mir completed 83 500 orbits in the 14.6 years before it crashed to Earth on 23 March 2001.

Question 1

Calculate the period of Mir's orbit in seconds.

1 mark

Question 2

Calculate the speed of Mir while in orbit.

 $(R_E = 6.37 \times 10^6 \text{ m})$

2 marks

**AREA 2 – continued
TURN OVER**

Question 3

Calculate the value of the gravitational field strength at 390 km above Earth's surface.

N kg^{-1}

2 marks

When Mir was in stable orbit, an object of mass 2.5 kg was placed on a spring balance that was attached to the inside of the space station.

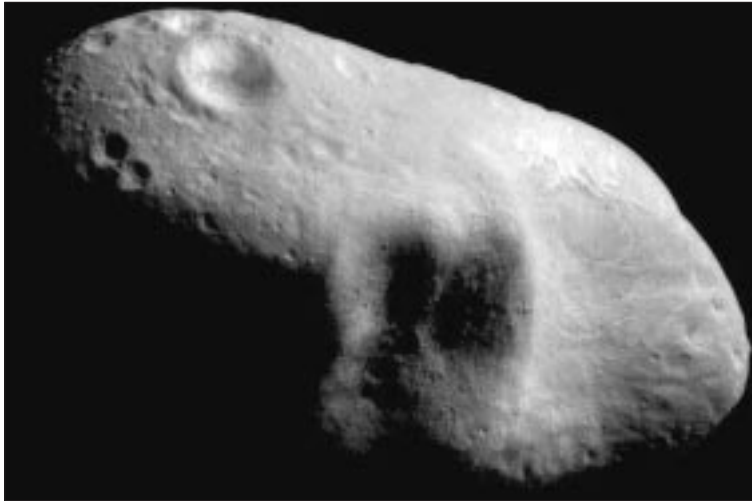
Question 4

What would be the weight shown on the spring balance? Explain your reasoning, or show your working, for determining the reading of the spring balance.

N

3 marks

On 12 February 2001, a spacecraft named the NEAR Shoemaker landed on Eros, a peanut-shaped asteroid (pictured) between the orbits of Earth and Mars. The 450 kg spacecraft had a weight of 2.5 N when it landed on the asteroid.



Eros

Question 5

Calculate the weight of this spacecraft on the surface of Earth.

($g = 9.8 \text{ N kg}^{-1}$)

N

2 marks

Before landing on Eros, the spacecraft orbited at a radius of 50 km from the centre of mass of Eros, with a period of 5.9×10^4 s (about 16 hours).

Question 6

Find the mass of Eros from this information.

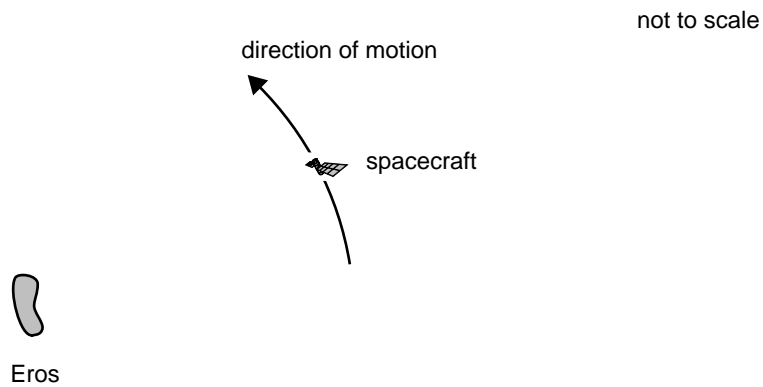
$(G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2})$

kg

3 marks

Question 7

On the diagram below, draw one or more labelled arrows to show any force(s) acting on the spacecraft as it orbits Eros. You can ignore any other astronomical bodies.



1 mark

AREA 3 – Structures and materials

The frame of a bush hut is shown below.

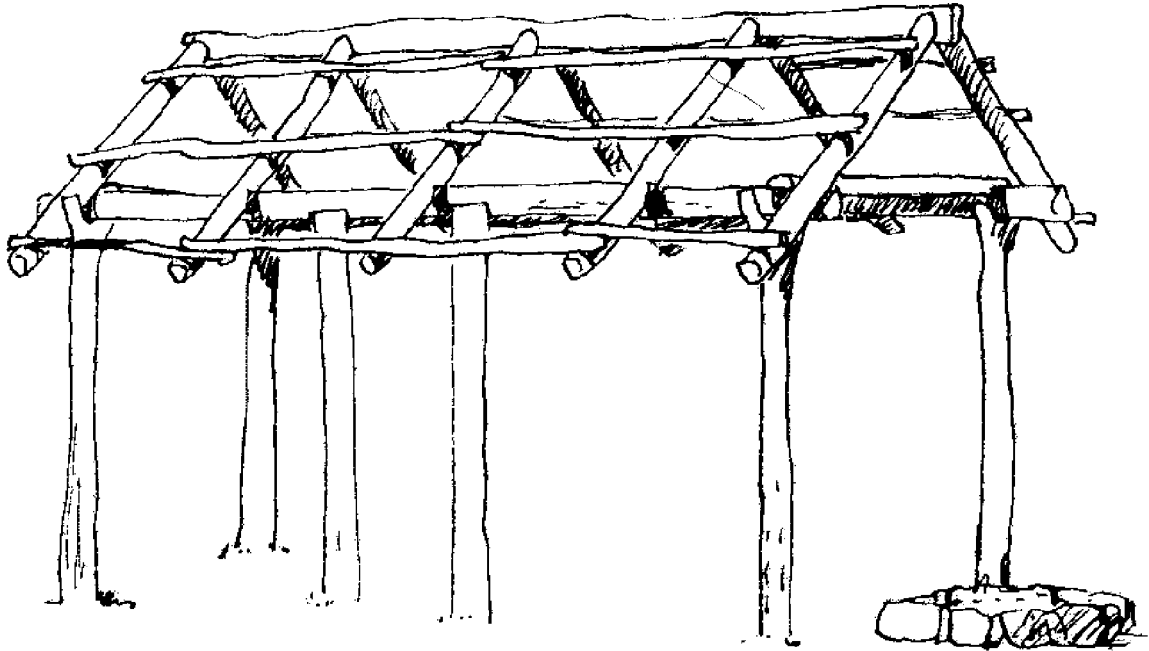


Figure 1

The roof is held up by four corner posts, each a forked tree trunk. In a detailed examination of such a structure, an engineer finds the force exerted by one of the roof beams on one side of the fork is 600 N in a direction perpendicular to the beam. A detailed section is shown in Figure 2.

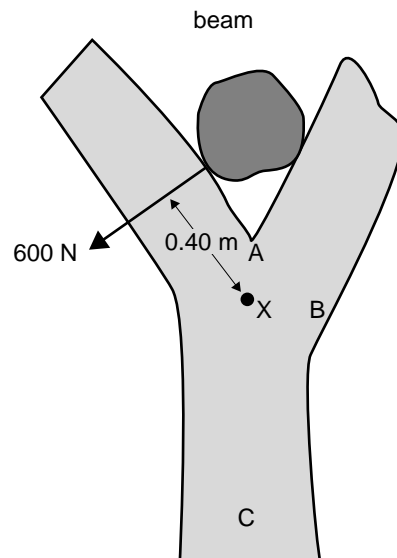


Figure 2

Question 1

Calculate the magnitude of the torque on the left side of the fork about the point **X**, due to the force from the roof beam.

N m

2 marks

Question 2

In the table below, indicate with a cross in the appropriate column whether the marked regions of the post are in tension, compression or neutral.

	tension	compression	neutral
A			
B			
C			

3 marks

Wood is considered to be a good building material.

Question 3

What structural properties should wood possess to be considered as a good building material?

3 marks

A mirror hangs on the wall of a room, as shown in Figure 3, suspended by two wires each at an angle of 40° to the vertical. The mirror has a mass of 20 kg.

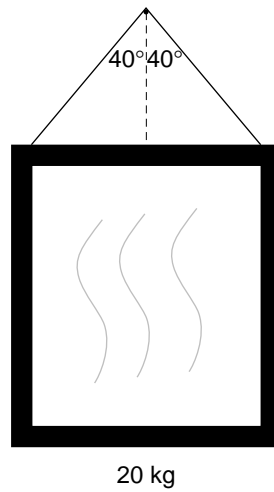


Figure 3

Question 4

Calculate the tension in each of the wires supporting the mirror.

($g = 9.8 \text{ N kg}^{-1}$)

N

3 marks

The stress-strain graph for a particular material is shown in Figure 4.

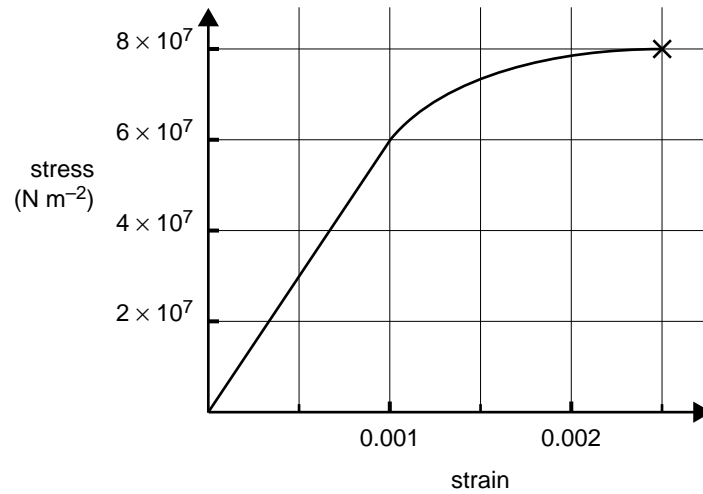


Figure 4

Question 5

Calculate the magnitude of Young’s Modulus for this material.

N m^{-2}

2 marks

Question 6

Estimate the energy per unit volume stored in the material up to the point of fracture, ✕.

J m^{-3}

3 marks

A survival course requires the participants to get a prize (1.0 kg of rice) suspended above a river. The diagram shows the problem.

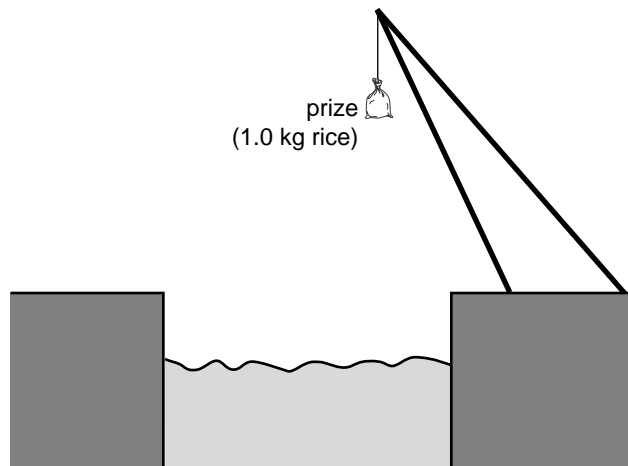


Figure 5

Question 7

Calculate the net force on the prize as it hangs.

 N

2 marks

Question 8

Calculate the tension in the string supporting the prize.

($g = 9.8 \text{ N kg}^{-1}$)

 N

2 marks

**AREA 3 – continued
TURN OVER**

Two participants in the course, Chris and Robin, arrive on the scene. They are allowed to use a 40 kg, 3.0 m long plank to reach the prize. They set up the plank with 1.0 m on the bank, and Robin is standing so that his centre of mass is 0.20 m from the end. The diagram shows Chris walking out on the plank.

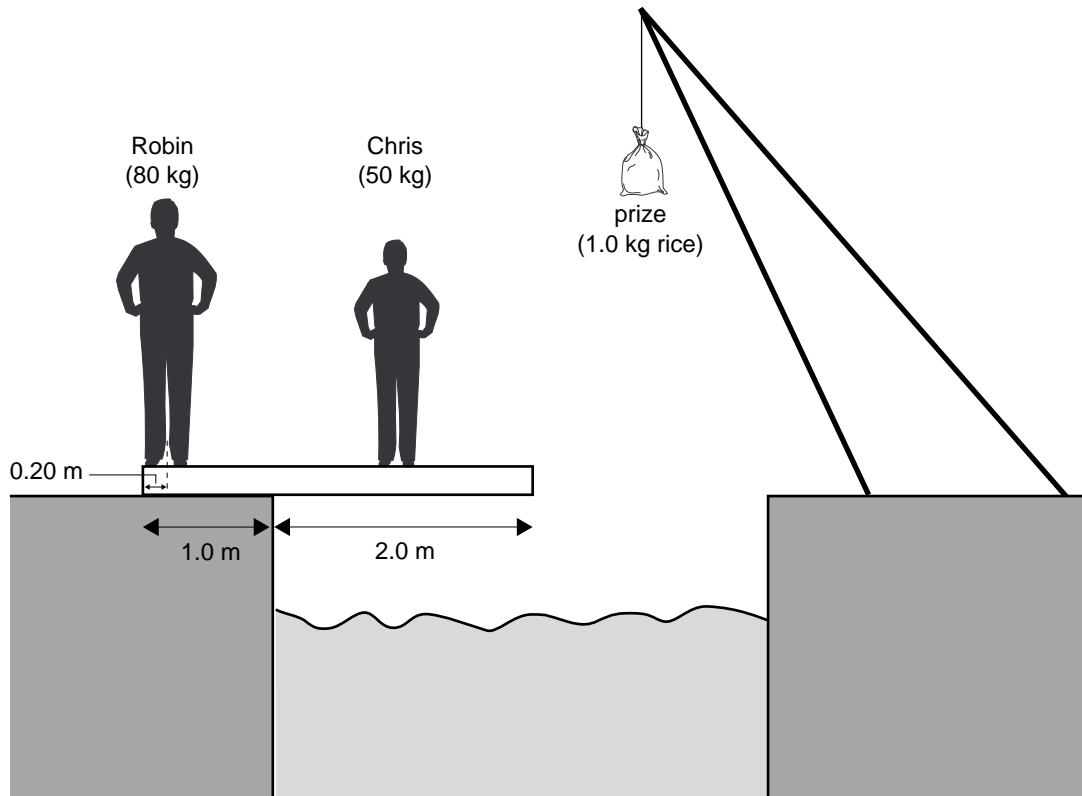


Figure 6

Question 9

Calculate how far from the bank Chris can safely walk.

m

4 marks

AREA 4 – Ideas about light and matter

In an electron microscope, electrons are accelerated from rest across a potential difference of 10 kV.

Question 1

Calculate the kinetic energy of an electron, in joule, after being accelerated from rest across a potential difference of 10 kV.

$$(e = 1.6 \times 10^{-19} \text{ C})$$

J

2 marks

Question 2

Calculate the de Broglie wavelength of an electron after being accelerated across 10 kV.

$$(m_e = 9.1 \times 10^{-31} \text{ kg}, \quad h = 6.63 \times 10^{-34} \text{ J s})$$

m

3 marks

A photoelectric effect experiment was performed with a plate of unknown metal. The following graph was formed from the results taken during the experiment.

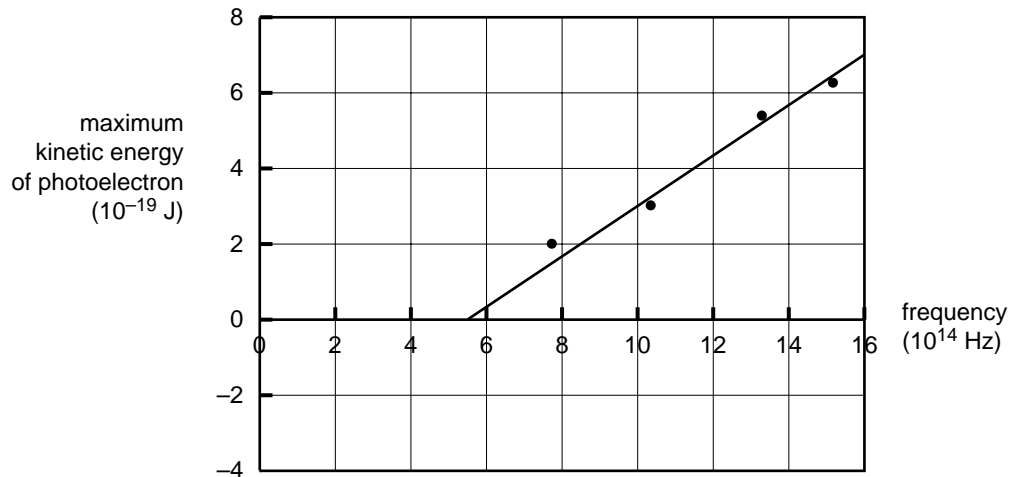


Figure 2

The cut-off frequency for this metal was found to be 5.5×10^{14} Hz.

Question 4

Determine the work function for this metal.

$$(h = 6.63 \times 10^{-34} \text{ J s})$$

	J
--	---

2 marks

The table below shows the corresponding wavelength for the cut-off frequency for different metal surfaces.

Metal	Wavelength (nm)
Caesium	682
Sodium	545
Zinc	405
Magnesium	345
Aluminium	303

Question 5

What is the metal that was used in the original data?

$$(c = 3.0 \times 10^8 \text{ m s}^{-1})$$

2 marks

Figure 3 is part of the emission spectrum for hydrogen taken from sunlight. Each emission line is displayed with the wavelength in units of nanometres (nm).

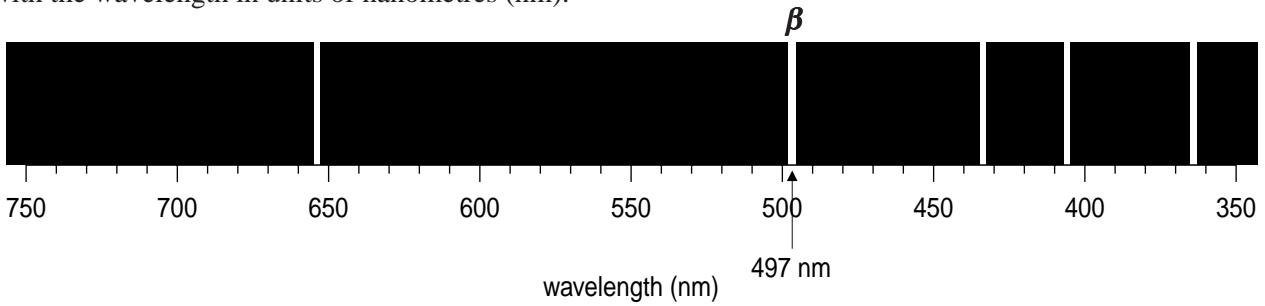


Figure 3

Question 6

Calculate the energy of the photon, in eV, that is indicated by the spectral line marked β in Figure 3.

$$(h = 4.14 \times 10^{-15} \text{ eV s}, \quad c = 3.0 \times 10^8 \text{ m s}^{-1})$$

eV

2 marks

Question 7

On the energy level diagram for hydrogen in Figure 4, indicate with an arrow (\downarrow) the energy level transition for the spectral line marked β in Figure 3.

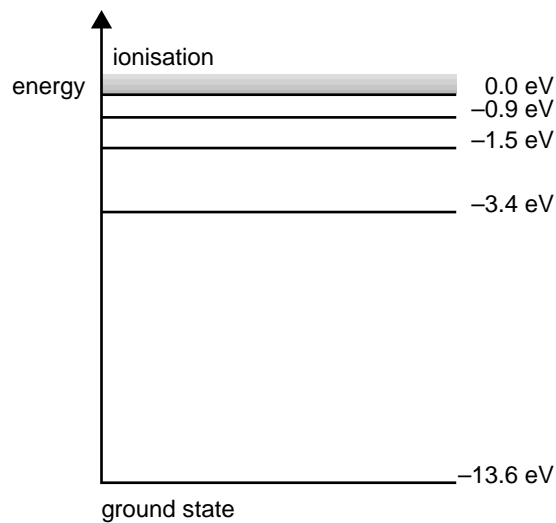


Figure 4

2 marks

PHYSICS

Written examination 2

DATA SHEET

Directions to students

Detach this data sheet before commencing the examination.

This data sheet is provided for your reference.

1	velocity; acceleration	$v = \frac{Dx}{Dt}; \quad a = \frac{Dv}{Dt}$
2	equations for constant acceleration	$v = u + at$ $x = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2ax$ $x = \frac{1}{2}(v + u)t$
3	Newton's second law	$F = ma$
4	circular motion	$a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$
5	Hooke's law	$F = -kx$
6	elastic potential energy	$\frac{1}{2}kx^2$
7	gravitational potential energy near the surface of the Earth	mgh
8	kinetic energy	$\frac{1}{2}mv^2$
9	torque	$\boldsymbol{\tau} = Fr$
10	Newton's law of universal gravitation	$F = G \frac{M_1 M_2}{r^2}$
11	gravitational field	$g = G \frac{M}{r^2}$
12	stress	$\boldsymbol{s} = \frac{F}{A}$
13	strain	$\boldsymbol{e} = \frac{DL}{L}$
14	Young's modulus	$E = \frac{\text{stress}}{\text{strain}}$
15	electric force on charged particle in an electric field	$F = qE$
16	electric field between charged plates	$E = \frac{V}{d}$
17	energy change of charged particle moving between charged plates	$\Delta E_k = qV$
18	photoelectric effect	$E_{k \max} = hf - W$
19	photon energy	hf
20	photon momentum	$p = \frac{h}{\lambda}$
21	de Broglie wavelength	$\lambda = \frac{h}{p}$

Gravitational field strength at the surface of Earth	$g = 9.8 \text{ N kg}^{-1}$
Universal gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Mass of Earth	$M_E = 5.98 \times 10^{24} \text{ kg}$
Radius of Earth	$R_E = 6.37 \times 10^6 \text{ m}$
Mass of the Sun	$M_{\text{SUN}} = 2.0 \times 10^{30} \text{ kg}$
Mass of the electron	$m_e = 9.1 \times 10^{-31} \text{ kg}$
Charge on the electron	$e = 1.6 \times 10^{-19} \text{ C}$
Planck's constant	$h = 6.63 \times 10^{-34} \text{ J s}$
	$h = 4.14 \times 10^{-15} \text{ eV s}$
Speed of light	$c = 3.0 \times 10^8 \text{ m s}^{-1}$

Prefixes/Units

$$\text{m} = \text{milli} = 10^{-3}$$

$$\mathbf{m} = \text{micro} = 10^{-6}$$

$$\text{n} = \text{nano} = 10^{-9}$$

$$\text{k} = \text{kilo} = 10^3$$

$$\text{M} = \text{mega} = 10^6$$

$$\text{G} = \text{giga} = 10^9$$

$$\text{tonne} = 10^3 \text{ kg}$$