Victorian Certificate of Education
2003

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

Figures									Letter
Words									

PHYSICS

Written examination 2

Tuesday 11 November 2003

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

Area	*Number of questions*	*Number of questions to be answered*	*Number of marks*
1. Motion	14	14	36
2. Gravity	4	4	15
3. Structures and materials	8	8	22
4. Light and matter	6	6	17
			Total 90

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, up to two pages (one A4 sheet) of pre-written notes (typed or handwritten) and an approved graphics calculator (memory cleared) and/or 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 book of 28 pages, with a detachable data sheet in the centrefold.

Instructions
- Detach the data sheet from the centre of this book during reading time.
- Write your **student number** in the space provided above on this page.
- 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.

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

AREA 1 – Motion

Figure 1 shows the speed vs time graph of a racing car accelerating through the gears with constant acceleration in each gear. The car was initially at rest.

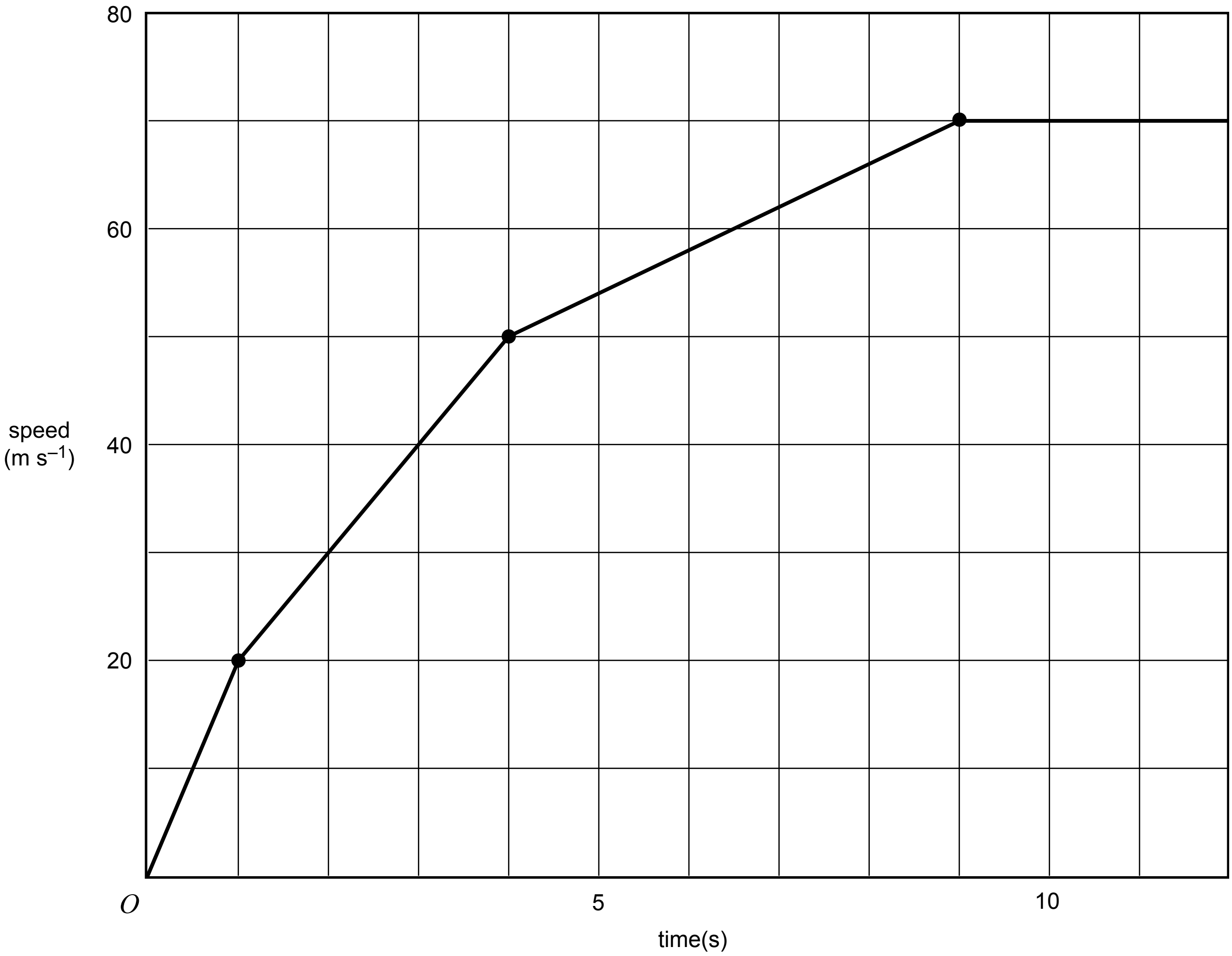


Figure 1

Question 1

Calculate the distance travelled by the car during the first **four** seconds of the motion.

m

2 marks

Question 2

Determine the magnitude of the acceleration of the car at $\boldsymbol{t}$ **= 3.0 s**.

$\boxed{\quad\quad\quad\quad\quad \text{m s}^{-2}}$

2 marks

Question 3

Calculate the average speed of the car during the first **twelve** seconds of the motion.

$\boxed{\quad\quad\quad\quad\quad \text{m s}^{-1}}$

3 marks

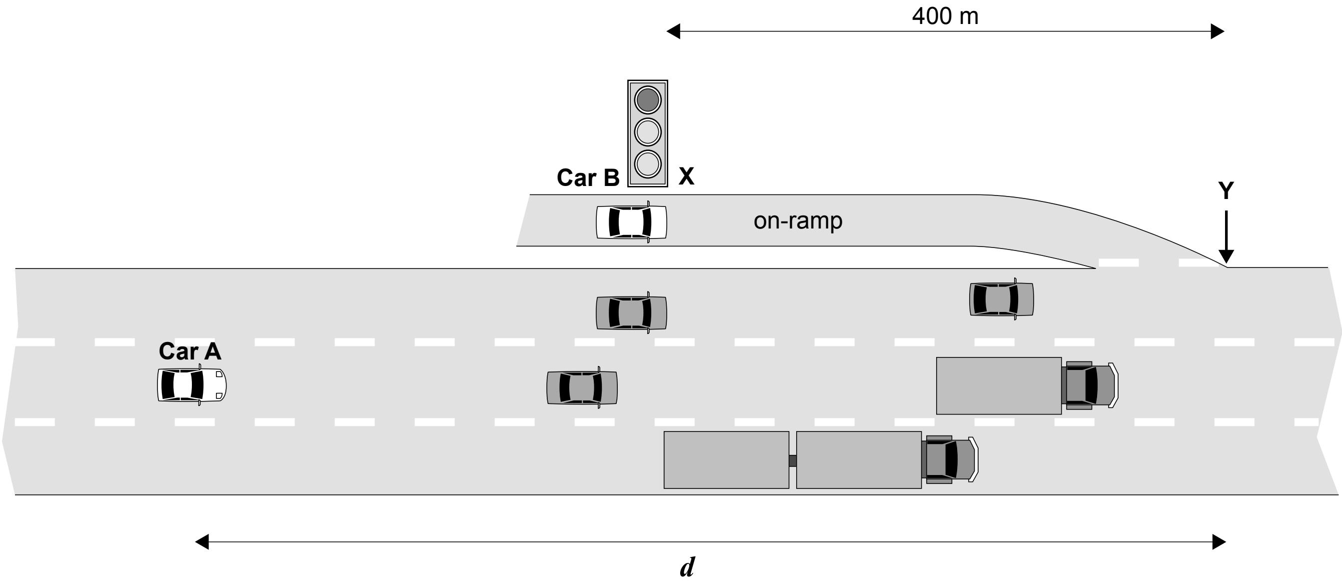


Figure 2

Figure 2 shows the merging lane of the on-ramp of a busy freeway. A set of traffic lights is installed at **X**, 400 m from **Y** where the cars merge into the traffic flow. The vehicles on the busy freeway are travelling at a constant speed of 80 km h^{-1}. When car **A**, a distance ***d*** along the road from point **Y**, is at the position shown, the traffic light at **X** changes to green. Car **B**, at the traffic light, is then expected to uniformly accelerate to 80 km h^{-1} at **Y** and merge into traffic beside car **A**.

Question 4

Calculate the distance ***d***. (You **must** show your working.)

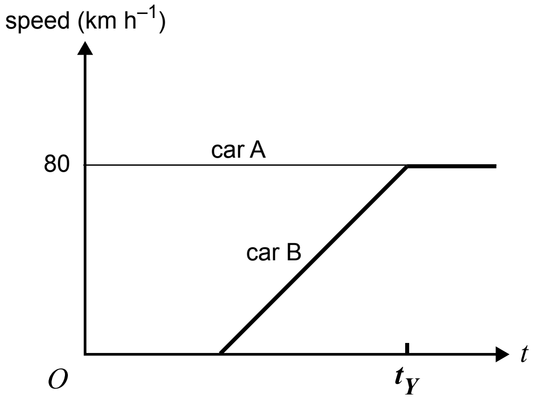
m

3 marks

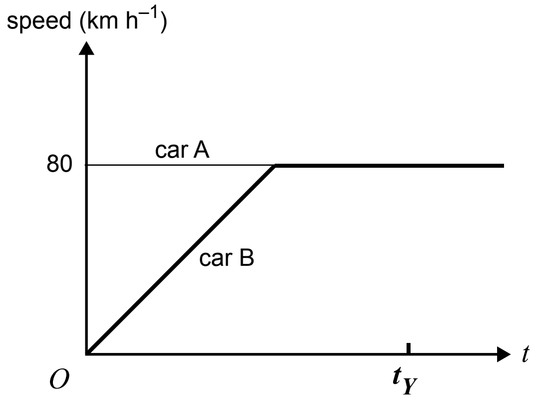
Question 5

Which of the speed–time graphs (**A.–D.**) best describes the motion of car **B** waiting at the traffic light and the motion of car **A**, from when the light changes to green ($t = 0$) until car **B** merges at time $\boldsymbol{t_Y}$.

A.



B.



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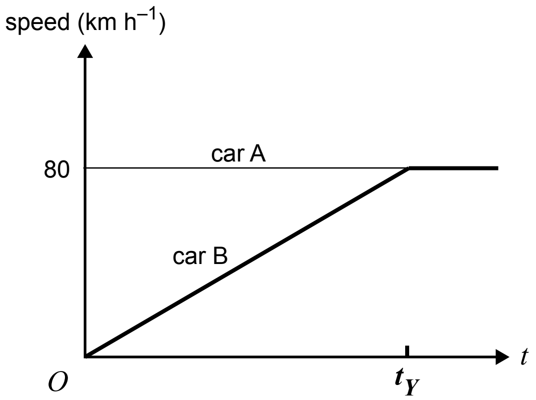
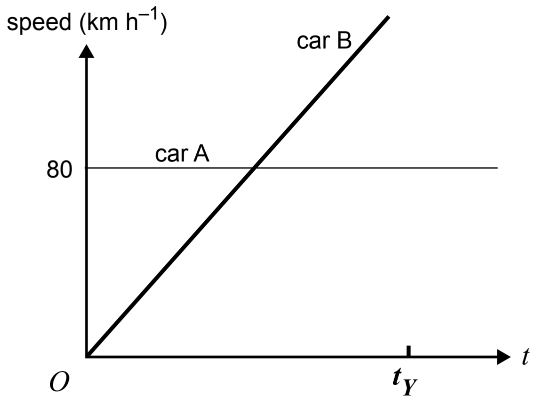


D.



2 marks

Kim is driving a dodgem car. He is travelling at 2.0 m s^{-1} when he hits an oil patch and collides head-on with the guardrail. The dodgem car (shown in Figure 3) has a spring-loaded bumper. After the collision the dodgem car rebounds directly backwards along the same line at a speed of 2.0 m s^{-1}. The spring constant of the bumper is 3.2×10^5 N m^{-1} and the mass of Kim and the dodgem car is 200 kg.

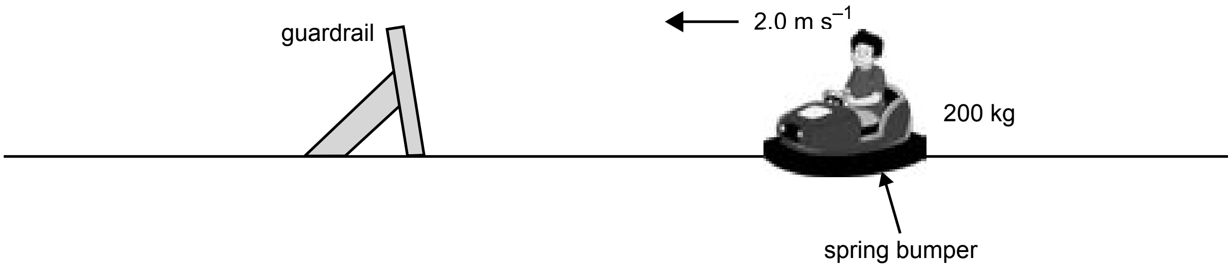


Figure 3

Question 6

Calculate the maximum compression of the bumper spring during this head-on collision.

m

3 marks

The law of conservation of momentum (for an isolated system) is a fundamental law of physics that applies to all collisions.

Question 7

Describe how you would show that the collision between the dodgem car and the guardrail satisfies the law of conservation of momentum. In particular, address these three aspects.

Initial momentum of dodgem car

Final momentum of dodgem car

Given the previous answers, explain how momentum is conserved.

4 marks

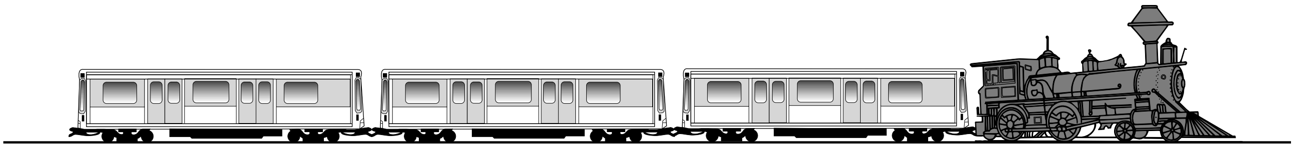


Figure 4

Figure 4 shows a train with an engine and three carriages travelling at constant velocity along a straight, level section of track. The mass of the engine is 40.0 tonnes and the mass of each of the carriages is 20.0 tonnes.

At this constant velocity the resistance forces on the engine (due to frictional forces and air resistance) total 5000 N and each carriage experiences a resistance force of 2000 N.

Question 8

What is the magnitude of the driving force provided by the engine?

N

2 marks

While still on the same section of track, the train is required to speed up and so the engine driving force is increased to 4.6×10^4 N.

Question 9

Calculate the acceleration of the train.

m s^{-2}

2 marks

During another part of the journey the train is accelerating at 0.20 m s^{-2} along a straight, level section of track.

Question 10

Calculate the magnitude of the tension in the coupling between the final two carriages during this acceleration. (Assume that the resistance forces remain unchanged.)

N

4 marks

A small car travels in a circle of radius 10.0 m at a constant speed. Figure 5a shows the car from **above** and Figure 5b shows the car from **behind**.

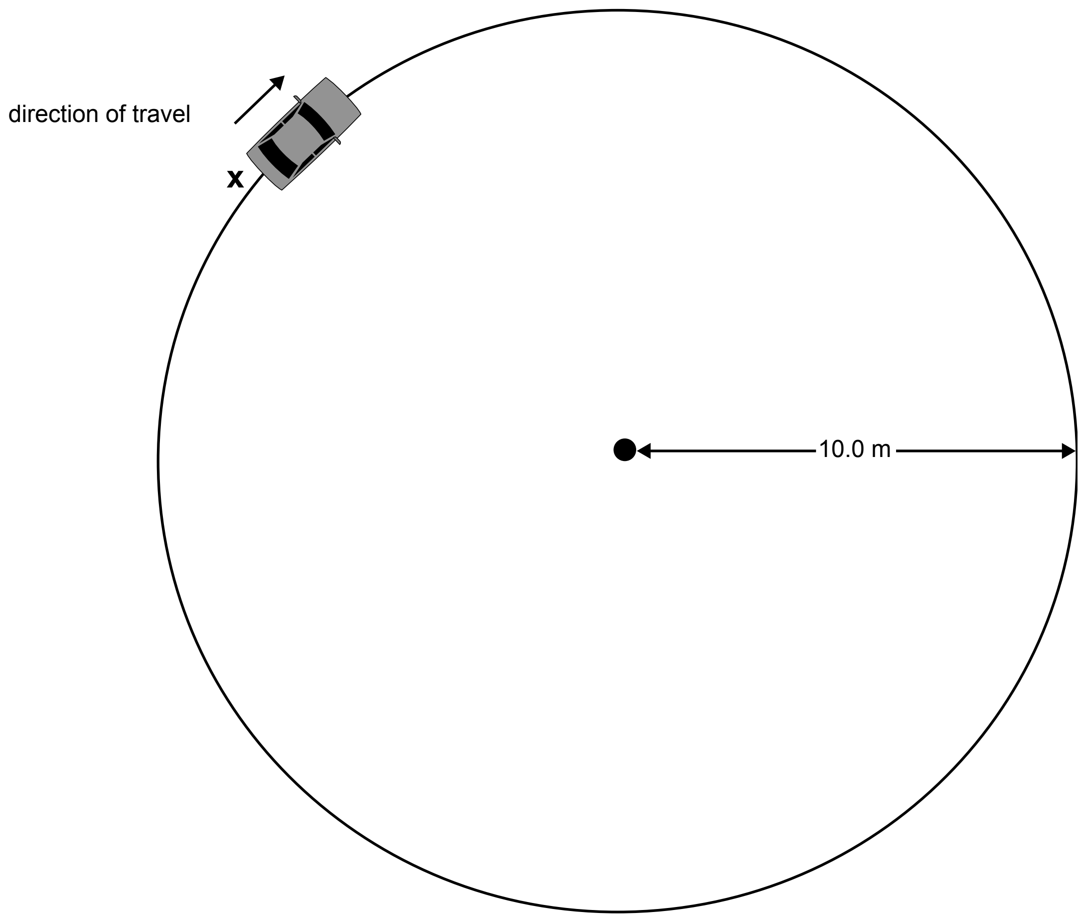


Figure 5a

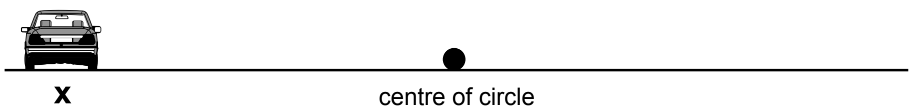
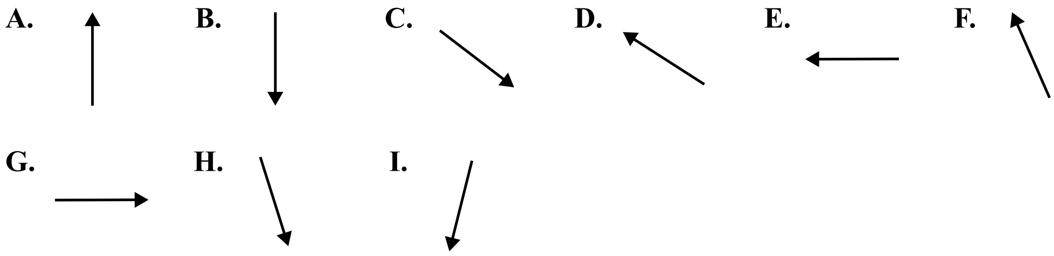


Figure 5b

Question 11

In the position **X**, shown in **Figure 5a**, which of the arrows (**A.–I.**) best shows the direction of the net force on the car?



2 marks

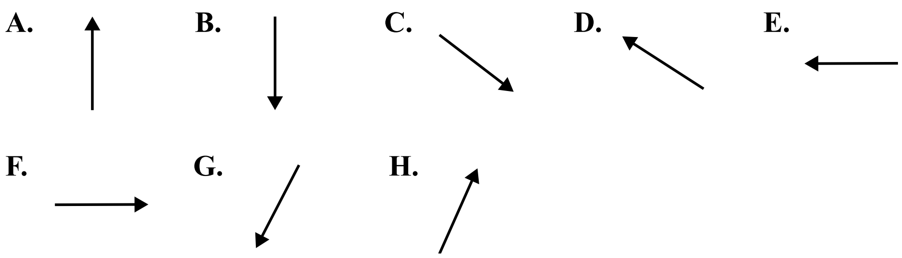
Question 12

On **Figure 5b**, draw arrows to show all the separate forces acting on the car at the position **X**, ignoring air resistance. (You must show both the **direction** and **point of application** of each separate force.)

2 marks

Question 13

In the position **X**, shown in **Figure 5b**, which of the arrows (**A.–H.**) best shows the direction of the force that the **tyre** exerts on the **road**.



2 marks

The car completes the circular motion and is now about to accelerate forward in a straight line.

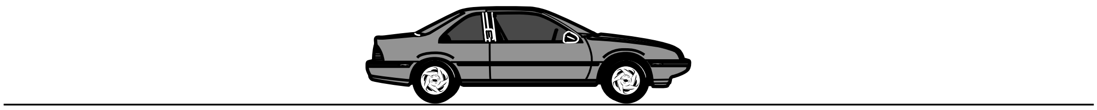


Figure 6

Question 14

Explain, giving clear reasons, how the movement of the wheels relative to the road enables the car to accelerate forward.

3 marks

END OF AREA 1

AREA 2 – Gravity

The spacecraft, Odyssey, has been in a circular orbit around Mars at an altitude of 400 km.

Question 1

Show that the period of this orbit is approximately 2 hours.

($R_{Mars} = 3.4 \times 10^6$ m, $M_{Mars} = 6.4 \times 10^{23}$ kg, $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2})

4 marks

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Figure 1 is a graph of the force of gravitational attraction between the 400 kg spacecraft Odyssey and the planet Mars versus distance above the surface of Mars.

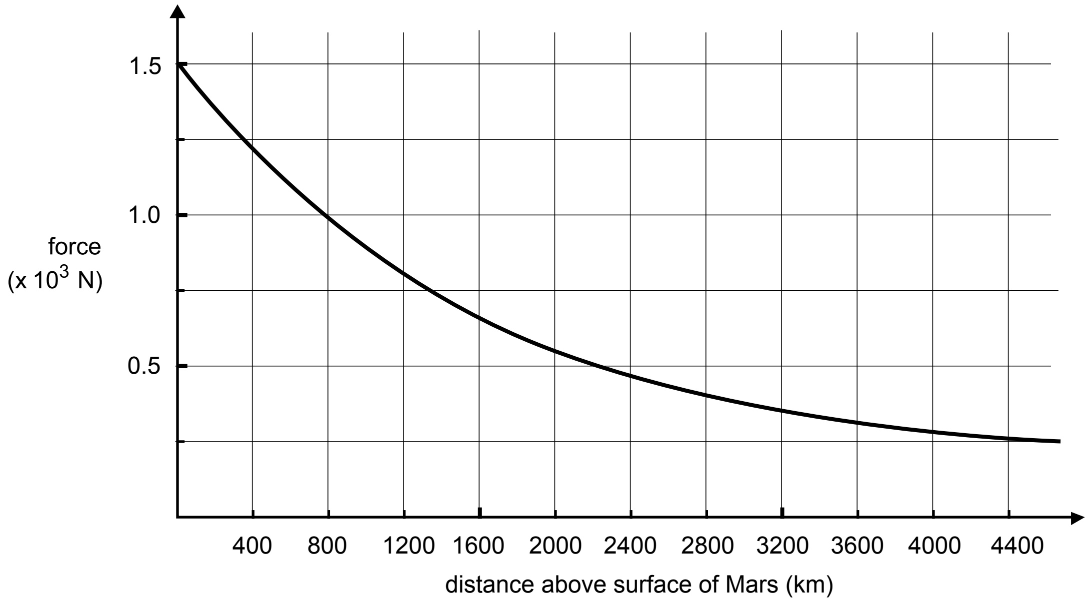

Figure 1

Before its orbit around Mars, Odyssey was originally launched from Earth and took 200 days to reach Mars. At a distance of 3200 km away from the surface of Mars it was travelling at approximately 24 000 m s^{-1}. At this point it was speeding up due to the gravitational attraction of Mars.

Question 2

Describe, **but do not calculate**, the method you would use to determine the speed of Odyssey at a distance of 1200 km above the surface of Mars.

4 marks

Last year astronomers discovered a new body, Quaoar, in our solar system just beyond Pluto. This very large asteroid orbits our Sun in a near perfect circle of radius 6.5×10^{12} m.

Question 3

Calculate the speed of Quaoar in its orbit around the Sun.

($G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}, $M_{\text{Sun}} = 2.0 \times 10^{30}$ kg)

m s^{-1}

3 marks

Two enthusiastic astronomy students, Kiera and Darla, were talking about what it would be like to travel and land on Quaoar. Both agreed that they would feel a very small gravitational effect if they were on the surface of Quaoar. However, Darla did not agree with Kiera's reason for the small gravitational effect.

Darla explained that a very small gravitational effect would be felt because Quaoar has such a small mass and that the gravitational force between the asteroid and himself would be very small.

Kiera explained that because Quaoar was in orbit around the Sun they would experience apparent weightlessness because both they and Quaoar would be accelerating towards the Sun at the same rate.

Question 4

Was Kiera correct or incorrect? Explain your answer.

4 marks

END OF AREA 2
TURN OVER

AREA 3 – Structures and materials

Figure 1 shows the brick and stone arched Richmond Bridge crossing the river at Port Arthur in Tasmania. This bridge has no steel reinforcing but it is very strong and has stood for over 180 years.

Figure 1

Question 1

Explain in terms of the properties of the brick, stone and arches, the features of this bridge that ensure that it is a strong, safe and stable structure.

3 marks

An architect wishes to design two walkways, one above the other, suspended from vertical rods attached to the ceiling of a hotel lobby. She is faced with a choice of designs. In the first design the two walkways are suspended from a single rod. In the second design two rods are used. Each walkway is suspended using pins through the rods as shown in Figures 2a and 2b. Each suspended section of a walkway has a weight of 5000 N.

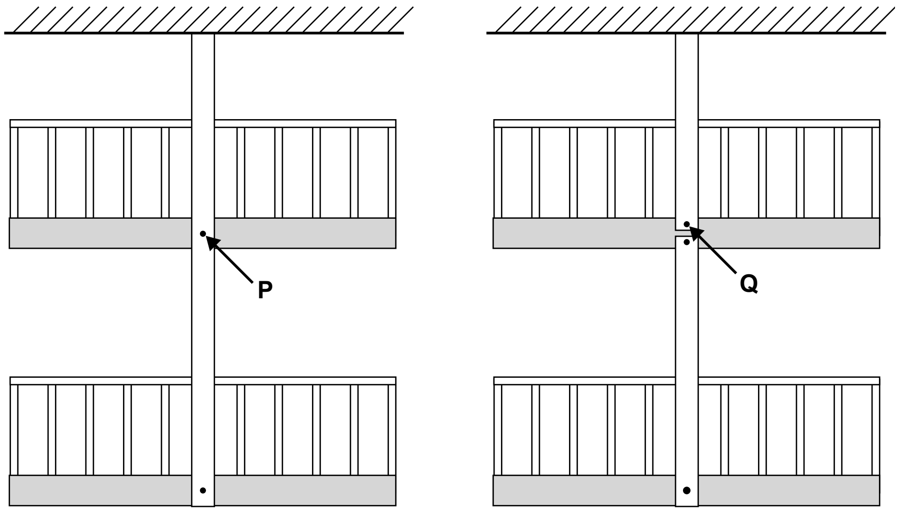

Figure 2a **Figure 2b**

Question 2

Calculate the force exerted by the rod on the upper pin **P** in **Figure 2a**.

N

2 marks

Question 3

Which of the descriptions (**A.–D.**) best describes the force exerted by the separate rods on pins **P** (**Figure 2a**) and **Q** (**Figure 2b**)?

A. The force exerted by the rod on pin **P** is half the force exerted by the rod on pin **Q**.

B. The force exerted by the rod on pin **P** is the same as the force exerted by the rod on pin **Q**.

C. The force exerted by the rod on pin **P** is equal but opposite to the force exerted by the rod on pin **Q**.

D. The force exerted by the rod on pin **P** is twice the force exerted by the rod on pin **Q**.

2 marks

A forest walk in Tasmania consists of an elevated steel walkway high above the ground. A uniform cantilever has been constructed so people can walk out over a river. The cantilever section is shown in Figure 3.

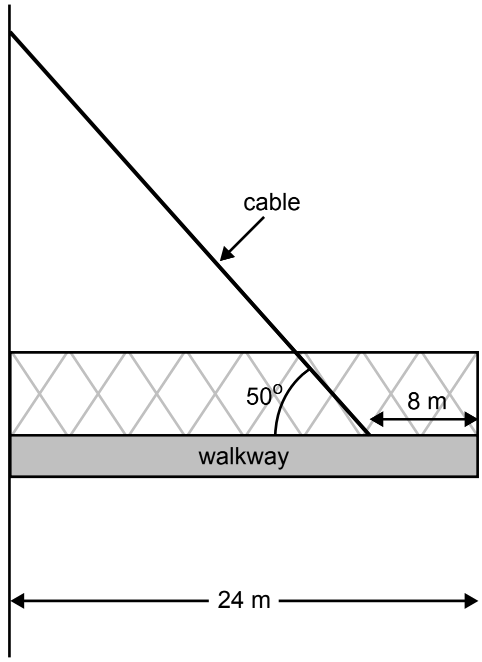

Figure 3

The cantilever is designed to support a load of 10 tonnes and is 24 m long. A single steel cable supports the cantilever, attached 8 m from the end at 50° as shown in Figure 3. The cantilever has a mass of 0.7 tonnes.

Question 4

If the cantilever is uniform and the maximum load of 10 tonnes is distributed evenly over the cantilever section, explain whether the cable will hold if the maximum tension the cable can withstand before breaking is 1.5×10^5 N. Support your answer with calculations. ($g = 9.8$ N kg^{-1})

4 marks

The cable that supports the cantilever can withstand a tension of 1.5×10^5 N before fracture. The cable has a length of 25 m and it is made of high tensile steel with a Young's modulus of 3.4×10^{11} N m^{-2}.

Question 5

Calculate the diameter of the cable if it is designed to stretch 10 mm just prior to fracture. (Assume that the behaviour of the cable is elastic up to the point of fracture.)

m

4 marks

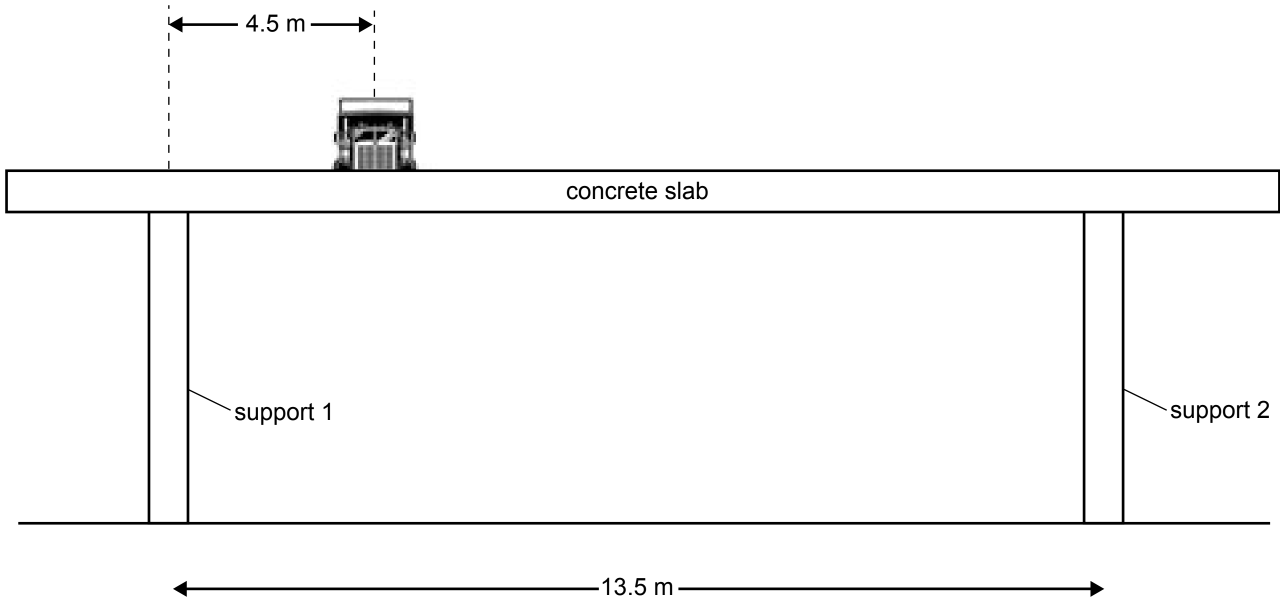

Figure 4

Figure 4 shows the front-on view of a loaded truck crossing a uniform concrete slab inside a building. The mass of the slab is 300 tonne, and the mass of the loaded truck is 50.0 tonne.

The centre of mass of the truck is 4.5 m from support 1.

Question 6

Calculate the magnitude of the contact forces supporting the slab when the centre of mass of the truck is 4.5 m from support 1. (g = 9.8 N kg^{-1})

Contact force support 1 = N	and	Contact force support 2 = N

3 marks

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The stress – strain graph for cast iron is shown in Figure 5.

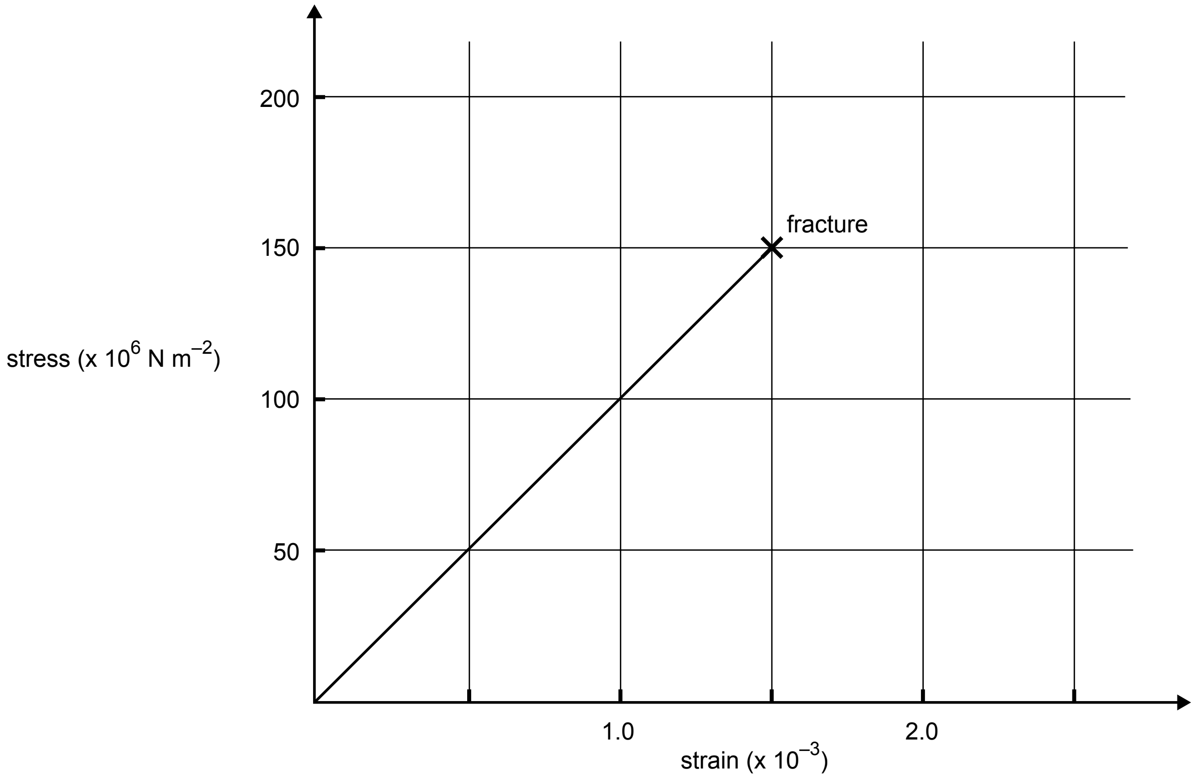

Figure 5

Question 7

Explain why cast iron can be described as brittle.

1 mark

A solid beam, shown in Figure 6, of dimensions 0.l0 m × 0.05 m × 10 m, is made of cast iron.

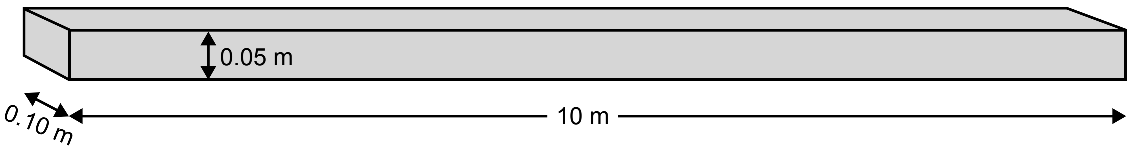

Figure 6

The beam is placed under a tensile stress until it fractures.

Question 8

Calculate the energy absorbed in this cast iron beam just prior to fracture.

	J

3 marks

END OF AREA 3
TURN OVER

AREA 4 – Light and matter

Part of the emission spectrum of sodium vapour produces a photon of energy 1.65 eV.

Question 1

Which **one** of the following transitions (**A–D**) on the energy level diagram of Figure 1 demonstrates the change in atomic energy levels for the emission of a photon of energy 1.65 eV?

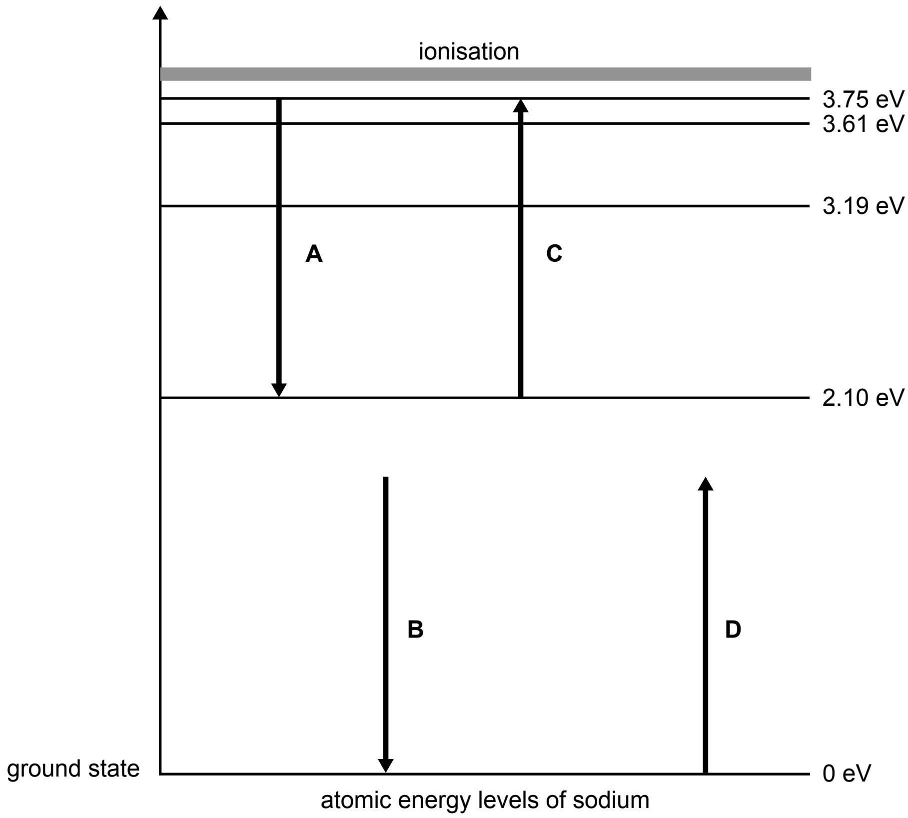

Figure 1

2 marks

The sodium atom is in the first excited state.

Question 2

Calculate the wavelength of the photon of energy emitted as the excited atom returns to the ground state.

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

m

3 marks

An electron gun accelerates electrons across a potential difference of 2500 V. The initial speed of the electrons can be considered to be almost zero.

Question 3

Show that the final speed of the electrons is approximately 10% of the speed of light.

($m_e = 9.1 \times 10^{-31}$ kg, $c = 3.0 \times 10^{8}$ m s^{-1}, $e = 1.6 \times 10^{-19}$ C)

4 marks

Katie and Jane are discussing wave-particle duality. Jane wonders whether wave-particle duality might explain why she missed hitting the softball in a recent match – maybe the wave nature of the softball allowed it to diffract around the bat! Katie said that this was not a reasonable explanation and that we cannot see the wave nature of a softball.

A softball has a mass of 0.20 kg and the pitcher throws it at about 30 m s^{-1}.

Question 4

Explain to Jane, using an appropriate calculation, why she would be unable to see the wave nature of a moving softball. ($h = 6.63 \times 10^{-34}$ J s)

3 marks

In an experiment to demonstrate the photoelectric effect, physics students allow light of various frequencies to fall on a metal surface in a photocell. The photoelectrons are decelerated across a retarding voltage, and the stopping potential, V_s, is measured for each frequency. The data they obtained is graphed in Figure 2.

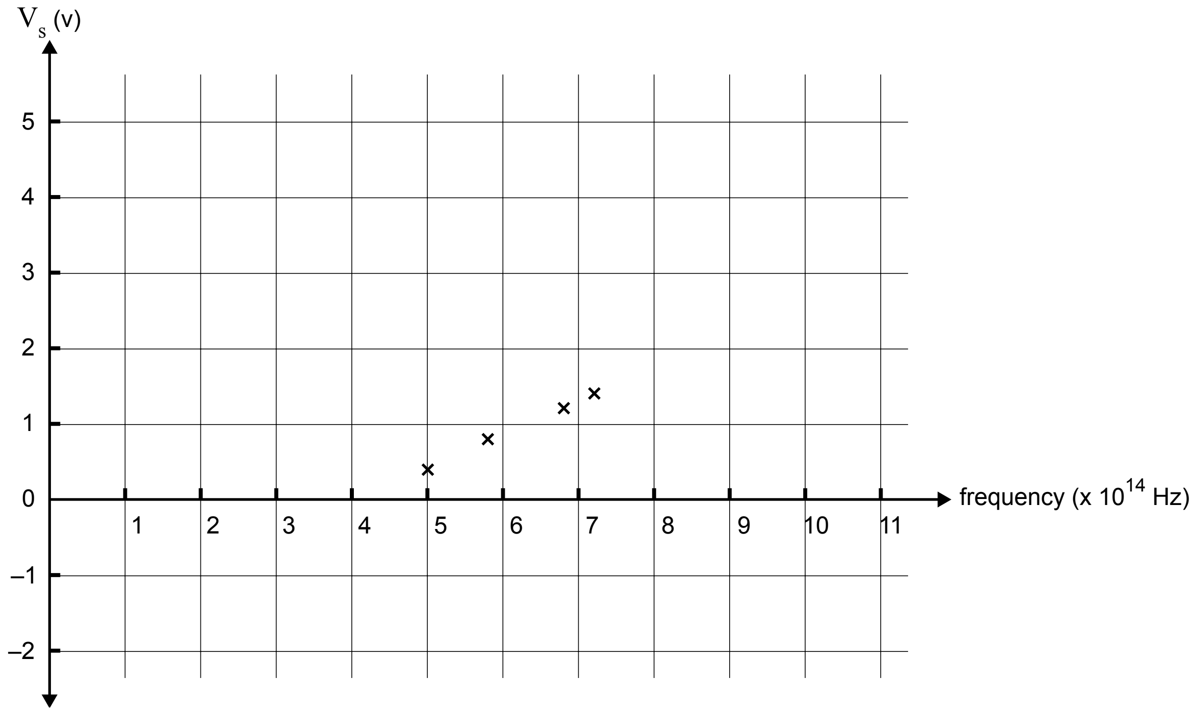

Figure 2

The students use the data points on the graph to determine a value for the work function of the metal.

Question 5

Determine the magnitude and unit of the work function for this metal surface.

Magnitude	Unit

2 marks

Question 6

What is the maximum kinetic energy (in eV) of the photoelectrons produced when ultraviolet light of frequency 1.93×10^{16} Hz is incident on the metal surface? ($h = 4.14 \times 10^{-15}$ eV s)

eV

3 marks

END OF QUESTION AND ANSWER BOOK