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**PHYSICS**

**UNITS 1 & 2**

**2021**

**MARKING GUIDE**

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Teacher: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***TIME ALLOWED FOR THIS PAPER***

Reading time before commencing work: Ten minutes

Working time for the paper: Three hours

***MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER***

**To be provided by the supervisor:**

* This Question/Answer Booklet; Formula and Constants sheet

**To be provided by the candidate:**

* Standard items: pens, pencils, eraser or correction fluid, ruler, highlighter.
* Special items: Calculators satisfying the conditions set by the SCSA for this subject.

***IMPORTANT NOTE TO CANDIDATES***

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

**Structure of this paper**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Section | Number of questions available | Number of questions to be answered | Suggested working time(minutes) | Marks available | Percentage of exam |
| Section One:Short answer | 13 | 13 | 50 | 55 | 30 |
| Section Two:Extended answer | 6 | 6 | 90 | 86 | 50 |
| Section Three:Comprehension and data analysis | 2 | 2 | 40 | 35 | 20 |
|  |  |  | **Total** | 176 | 100 |

**Instructions to candidates**

1. The rules for the conduct of Western Australian external examinations are detailed in the *Year 11 Information Handbook 2021.* Sitting this examination implies that you agree to abide by these rules.
2. Write your answers in this Question/Answer Booklet.
3. When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

 When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.

1. You must be careful to confine your responses to the specific questions asked and follow any instructions that are specific to a particular question.
2. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
	* Planning: If you use the spare pages for planning, indicate this clearly.
	* Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Refer to the question(s) where you are continuing your work.

**Section One: Short response 30% (55 Marks)**

This section has **thirteen (13)** questions. Answer **all** questions. Write your answers in the space

provided. Suggested working time for this section is 50 minutes.

1. **(4 marks)**

Justify whether the following statement is true or false: At the same temperature, atoms of helium move faster, on average, than atoms of xenon.

To be at the same temperature, the helium atoms have the same average kinetic energy as xenon atoms 1

Helium atoms are lighter than xenon atoms so have lower KE at any given speed 1

To have the same average kinetic energy, the lighter helium atoms must be moving faster

 1

Thus the statement is true 1

1. **(4 marks)**

A student is disappointed that he received zero marks in a test question for drawing the diffraction diagram below. In the space below, draw a correct diagram. Note: the frequency for each diagram is different but the gap is the same width.



 Diagram 1 Diagram 2

|  |  |
| --- | --- |
| **Description** | **Marks** |
| wavefronts are constant spacing for both | 1 |
| wavefronts are spherical for both | 1 |
| greater diffraction angle for Diagram 1 | 1 |
| **Total** | **3** |

1. **(6 marks)**

A soft drink company monitors the volume of soft drink added to cans by using a radioisotope. Radiation is directed through the can, near the top. A detector on the other side of the can monitors for radioactivity. When the detector picks up a significant drop in radioactivity as a can passes by, this is an indication the soft drink can was full.

1. State which type of radiation would be suited to this application. Justify your choice.

Beta 1

Beta can penetrate through thin aluminium and air, but not through any additional soft drink

**OR**

Alpha and gamma have too little and too much penetrating power respectively which will not be impacted by soft drink’s presence 1

When beta is stopped by the soft drink, this would cause a drop in radioactivity at the detector, confirming the can has been filled. 1

1. For this application, state whether it would be better to have a radioisotope with a half life of 2 weeks or 2 years. Justify your choice.

2 years 1

The longer half life will have a more consistent activity 1

The detector will be less likely to read a can as full, despite being empty if the activity drops too low. 1

**OR**

2 years 1

The longer half life will mean the source will not be replaced as often 1

This is safer as there is less handling of radioactive material/less costly or time consuming 1

**Question 4 (7 marks)**

(a) Draw a graphical representation of the soundwave on the axes provided above. Determine the scale on the x-axis using the data provided. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Draws sine-wave that accurately mirrors grey bands in diagram | 1 |
| Correctly labels x-axis at suitable locations | 1 |
| **Total** | **2** |

(b) Calculate the wavelength and frequency of the wave. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Pressure Distance (m)  0.30 m 0.60 m 0.90 m 1.20 m |
| Calculates wavelength to 0.150 x 2 = 0.300 m | 1 |
| f = v/$λ$  | 1 |
|  = 342 / 0.300 | 1 |
|  = 1140 Hz | 1 |
| **Total** | **4** |

(c) Select the direction of the movement of air molecules during the transmission of energy in this wave from the options below. (1 mark)

A B C D

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Answer: C | 1 |
| **Total** | **1** |

**Question 5** **(7 marks)**

Ms Collins is doing a food shop at Coles. Seeing an item on her list, she pushes her 12.5 kg trolley from rest up to 1.70 m s-1.

1. Calculate the work done by Ms Collins on the trolley. (2 marks)

$W=∆E=\frac{1}{2}mv^{2}-\frac{1}{2}mu^{2}$ 1

$W=\frac{1}{2}×12.5×1.70^{2}-0=18.06=18.1 J$ 1

1. The trolley was moved 3.20 m during the acceleration. Calculate the average power at which Ms Collins transferred energy to the trolley. If you could not obtain an answer to part (a), use 18.5 J. (3 marks)

$v\_{av}=\frac{u+v}{2}=\frac{0+1.70}{2}=0.850 m s^{-1}$ 1

$W=Fs$

$F=\frac{W}{s}=\frac{18.06}{3.20}=5.644 N$ 1

$P=Fv\_{av}=5.644×0.850=4.80 W$ 1

**OR**

$v^{2}=u^{2}+2as$

$a=\frac{v^{2}-u^{2}}{2s}=\frac{1.70^{2}-0}{2×3.20}=0.4516 m s^{-2}$ 1

$v=u+at$

$t=\frac{v-u}{a}=\frac{1.70-0}{0.4516}=3.764 s$ 1

$P=\frac{W}{t}=\frac{18.06}{3.764}=4.80 W$ 1

**Question 6** **(4 marks)**

The threshold of pain for human hearing occurs when sound is at an intensity of 10.0 W m-2. A jet engine produces a sound intensity of 562 W m-2 at a distance of 2.00 m from the engine.

1. Describe how sound intensity varies with distance from the source. (1 mark)

Sound intensity is proportional to the inverse of distance squared. 1

1. Calculate how far from a jet engine the intensity of its sound will drop below the threshold of pain. (3 marks)

$I∝\frac{1}{r^{2}}$

$∴I\_{1}r\_{1}^{2}=I\_{2}r\_{2}^{2}$

$562×2.00^{2}=10.0×r\_{2}^{2}$ 1-2

$r\_{2}=15.0 m$ 1

**Question 7** **(4 marks)**

Describe the difference between a longitudinal wave and a transverse wave. Provide an example of each type of wave to support your answer.

A longitudinal wave has vibrations/disturbances that oscillate in the same direction as the propagation of the wave. 1

Suitable example (sound in air, compressed slinky) 1

A transverse wave has vibrations/disturbances that oscillate perpendicular to the propagation of the wave. 1

Suitable example (ripples, string) 1

**Question 8** **(4 marks)**

Calculate the net force acting on the plane shown in the free body diagram below. Treat up the page as the north direction.

800 N

600 N

$$θ$$

Thrust

3000 N

Drag

2400 N

Cross wind

800 N

$F\_{north}=3000-2400=600 N$ 1

$\sum\_{}^{}F=\sqrt{800^{2}+600^{2}}=1000 N$ 1

$θ=tan^{-1}\left(\frac{800}{600}\right)=53.1^{0} $ 1

$Direction is 53.1^{0} T (or N 53.1^{0} E)$ 1

**Question 9 ( 3 marks)**

(a) Which of the velocity-time graphs shown below best represent an object released from a position 10 meters above the ground and allowed to fall freely.

 (1 mark)



D

C

B

A

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Answer: D | 1 |
| **Total** | **1** |

(b) On the graphs below, sketch the displacement-time graph and the acceleration time graph of the object as it falls. (2 marks)

s (m) a (m s-2)

 t (s) t (s)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Sketch 1 correct | 1 |
| Sketch 2 correct | 1 |
| **Total** | **2** |

 **(4 marks)**

**Question 10** **(4 marks)**

A closed pipe is 1.35 m long and 15.0 cm in diameter.

1. Calculate the wavelength of the fundamental wave that would resonate in the pipe.

 (2 marks)

$λ=\frac{4l}{(2n-1)}=\frac{4×1.35}{1}=5.40 m$ 1-2

1. Calculate the length of an open pipe that could produce the same fundamental frequency as the closed pipe as in part (a). (2 marks)

$λ=\frac{2l}{n}$

$l=\frac{nλ}{2}=\frac{1×5.40}{2}=2.70 m$ 1-2

**Question 11** **(4 marks)**

A world class sprinter can burst out of the starting blocks to his top speed of 11.5 m s-1 in the first 15.0 m of the race. Calculate the average acceleration of the sprinter and the time it takes to reach that speed.

|  |  |
| --- | --- |
| **Description** | **Marks** |
| a = v2 – u2 = 11.52 2s 2(15) | 1 |
|  = 4.41 m s-2 | 1 |
| t = v – u = 11.5 - 0 a 4.41 | 1 |
|  = 2.61 s  | 1 |
| **Total** | **4** |

**Question 12** **(6 marks)**

(a) When it is at a height of ¾ h from the ground, determine the ratio of Ek to Ep at that point. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Ep + Ek = ETmg(3/4) h + ½ mv2 = constant | 1 |
| = ¾ : ¼ = 3 : 1 | 1 |
| **Total** | **2** |

(b) Determine the height in terms *h* when the speed of the stone is half of the initial velocity *u.*

(4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| ETi = ETF­½ mu2 = ½ m(1/2u)2 + mgh | 1 |
| mgh = ½mu2 – ½m(1/4u2)  | 1 |
| gh = ½u2 – 1/8 u­2  | 1 |
| h = 3/8u2  g | 1 |
| **Total** | **4** |

 **End of Section 1**

**Section Two: Problem-solving 50% (86 Marks)**

This section has **six (6)** questions. You must answer **all** questions. Write your answers in the

space provided. Suggested working time for this section is 90 minutes.

**Question 14 (10 marks)**

Thermodynamic properties of three alcohols are listed in the table below. You have a 100 g sample of each alcohol but are concerned the labels have been mixed up. You have access to a low temperature freezer that can be set between -150 0C and -20 0C, a calorimeter that can measure the amount of heat applied to a sample, and thermometers.

|  |  |  |
| --- | --- | --- |
| **Alcohol** | **Liquid Specific Heat Capacity****(J kg-1 K-1)** | **Melting point****(0C)** |
| 1-propanol | 2400 | -126 |
| 2-propanol | 2570 | -90 |
| 1-butanol | 2400 | -90 |

1. Describe a method to identify the 1-propanol sample from the other alcohols based on their thermodynamic properties. (2 marks)

Put all alcohols in the freezer below -90 0C and above -126 0C. 1

The alcohol that is in a liquid state is 1-propanol 1

1. Describe a method to identify the 2-propanol from the other alcohols based on their thermodynamic properties. In your description, include the useful states of matter, measurements and/or calculations performed. (4 marks)

Start the alcohols in their liquid state (controlled 1

Apply heat and record using the calorimeter 1

Measure the temperature change of all samples 1

Using $Q=mc∆T$, calculate the specific heat capacity of the alcohols and use the table to identify the sample

**OR**

The alcohol that had the smallest temperature change for equal amounts of applied heat is the 2-propanol due to it having the highest specific heat capacity 1

1. The sample of 1-propanol at -45.0 0C is added to the 2-propanol sample at 10.0 0C. Calculate the final temperature of the mixture. (4 marks)

$∆Qgained= ∆Qlost$

$mc∆T\_{1-propanol}=mc∆T\_{2-propanol}$ 1

$0.1×2400×\left(T-(-45)\right)=0.1×2570×(10-T)$ 1-2

$240T+10800=2570-257T$

$T= -16.6^{ 0}C$ 1

**Question 15** **(10 marks)**

The triple-alpha process is a set of nuclear reactions that occur in the cores of stars in which three alpha particles are transformed into carbon. The first reaction is the fusion of two alpha particles to form Be-8. This reaction requires an input of 0.0918 MeV, taken from the star’s core. A third alpha particle fuses with Be-8 to form C-12. This second reaction releases 7.37 MeV.

1. State the composition of an alpha particle. (1 mark)

2 protons and 2 neutrons 1

1. Write the first reaction of the triple-alpha process. (2 marks)

$$ 1-2

1. Calculate the mass, in kilograms, gained by the fusion of the first two alpha particles.

 (3 marks)

$E=mc^{2}$ 1

$m=\frac{E}{c^{2}}=\frac{0.0918×10^{6}×1.6×10^{-19}}{\left(3.00×10^{8}\right)^{2}}=1.63×10^{-31} kg$ 1-2

1. Write the second reaction of the triple-alpha process. (2 marks)

$+ $ 1-2

1. Calculate the net energy released by a completed triple-alpha process. (2 marks)

$∆E=7.37-0.0918$ 1

$∆E=7.28 MeV$ 1

 1

**Question 15 (10 Marks)**

Consider the two circuits below which, have identical emf sources and globes.

$$V\_{T}$$

$$V\_{T}$$

Circuit B

Circuit A

1. Redraw circuit A below with an ammeter and voltmeter included. The ammeter and voltmeter need to allow for the measurement of the current and voltage of a single globe.

 (2 marks)

Ammeter anywhere in series with circuit elements 1

Voltmeter attached in parallel with a single globe 1

1. Determine the equivalent resistance of the circuit in terms of the resistance of a single globe, R. Show clear working.

* + 1. For Circuit A (2 marks)

$R\_{T}=R+R+R=3R$ 1-2

* + 1. For Circuit B (2 marks)

$R\_{T}=\left(\frac{1}{R}+\frac{1}{R}+\frac{1}{R}\right)^{-1}=\frac{R}{3}$ 1-2

1. By determining an expression for the power dissipated by a globe from each circuit in terms of the resistance of a single globe (R) and the voltage of the emf source (VT), determine which circuit will produce a brighter light for a single globe. You can assume the light bulbs are of the same resistance and are Ohmic. (4 marks)

In circuit A, for each globe:

$I=\frac{V\_{T}}{3R} and V=\frac{V\_{T}}{3} $ 1

$P=VI=\frac{V\_{T}^{2}}{9R} $ 1

In circuit B, for each globe:

$I=\frac{V\_{T}}{R} and V=V\_{T} $ 1

$P=VI=\frac{V\_{T}^{2}}{R}$ 1

$\frac{V\_{T}^{2}}{R}>\frac{V\_{T}^{2}}{9R}$ therefore circuit B is brighter. 1

**Question 16 (16 marks)**

The reconstruction of a traffic accident based on the testimonies of eyewitnesses and evidence found on the road is shown below in three stages; before the collision, at the moment of impact, and after the collision. The skid marks seen in the diagrams reveal the distance over which Car 1 was braking hard. Car 1 has a maximum braking force of 16800 N. You may assume that Car 1 only ever applied the full force of its brakes.

Car 1

Car 2

Before collision

$$m=1200 kg v=75 km h^{-1}$$

$$m=950 kg v=0 km h^{-1}$$

13.0 m

Car 1

Car 2

Moment of impact

13.0 m

1.50 m

5.00 m

Car 1

Car 2

After collision

1. Explain whether a car crash is an example of an elastic or inelastic collision. (3 marks)

An inelastic collision occurs when kinetic energy is not conserved 1

In a car crash, kinetic energy will be converted into heat/sound/deformation of the car body.

 1

Thus a car crash is an example of an inelastic collision 1

1. Show that the velocity at which Car 1 collided with Car 2 is approximately 8 m s-1. (4 marks)

$75 km h^{-1}=20.833 m s^{-1}$ 1

Deceleration during braking

$a=\frac{F}{m}=\frac{16800}{1200}=14.0 m s^{-1}$ 1

Velocity at impact

$v^{2}=u^{2}+2as$

$v^{2}=20.833^{2}+2×\left(-\right)14.0×13.0$ 1

$v=8.37 m s^{-1}$ 1

1. Calculate the velocity of Car 1 just after the moment of impact. (2 marks)

$v^{2}=u^{2}+2as$

$0^{2}=u^{2}+2×\left(-\right)14.0×1.50$ 1

$u=6.48 m s^{-1} $ 1

1. Hence, calculate the velocity of Car 2 just after the moment of impact. If you could not determine an answer to part (c) you may use 6.50 m s-1. (3 marks)

$\sum\_{}^{}p\_{before}=\sum\_{}^{}p\_{after} $

$mu\_{car 1}=mv\_{car 1}+mv\_{car 2}$ 1

$1200×8.37=1200×6.48+950×v$ 1

$v=2.39 m s^{-1} (2.36 m s^{-1})$ 1

1. Explain how a car’s crumple zone would have reduced the chance that the driver of Car 1 was significantly injured. (4 marks)

The crumple zone of a car is designed to deform during a collision 1

This increases the time in which the car will experience the change in momentum/impulse 1

As time of the collision increases, the force of the impact will reduce ($I=\uparrow F \downright t$) 1

With less force, the chance of injury will be less 1

**Question 17 (13 marks)**

A rock is dropped into the middle of a calm lake, creating ripples that are 14.0 cm apart. The wave ripples, as they pass by a cork on the lake’s surface, are shown as a function of time in the graph below.

1. For each time given below, circle the best description of the relative speed of the cork and circle the best description of the direction of the cork’s velocity.
	1. 1.500 s (2 marks)

|  |  |
| --- | --- |
| **Relative** **speed** | **Direction** |
| Large Small Zero | Up Down Left Right Not applicable |

* 1. 1.125 s (2 marks)

|  |  |
| --- | --- |
| **Relative** **speed** | **Direction** |
| Large Small Zero | Up Down Left Right Not applicable |

* 1. 2.500 s (2 marks)

|  |  |
| --- | --- |
| **Relative** **speed** | **Direction** |
| Large Small Zero | Up Down Left Right Not applicable |

1. Calculate the frequency of the wave. (2 marks)

$T=1.50 s (from graph)$ 1

$f=\frac{1}{T}=\frac{1}{1.50}= 0.6667=0.667 Hz$ 1

1. Hence, calculate the velocity of the wave. If you could not obtain an answer to part (b), use 0.700 Hz. (2 marks)

$v=λf$

$v=0.14×0.6667=0.0933 m s^{-1} (0.0980 m s^{-1})$ 1-2

1. By referring to the wave equation, describe the changes that would happen to the properties of the wave should the frequency of the ripples of a second rock be twice the magnitude of the first rock. (3 marks)

$v=λf$ 1

Velocity of the wave remains constant for any given medium 1

If the frequency doubles, the wavelength halves 1

**Question 18 (15 marks)**

1. Sketch labelled particle displacement envelopes for the first three harmonics produced.

 (3 marks)

|  |
| --- |
| **Diagram  Description automatically generated** |
| **Description** | **Marks** |
| Shape for all are correct: antinodes at tube end, nodes at water level | 1 |
| All three envelopes have common wavelengths | 1 |
| Regions of Nodes and Anti-nodes labelled. | 1 |
| **Total** | **3** |

(b) Determine the speed of sound in air in the pipe from the experimental results. Ignore any end error in this scenario. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| 2$ λ$ = L2 – L1 = L3 – L2 = 2(L3 – L1) $ λ$ = 0.708 m | 1 |
| v = f $λ$ = 495 x 0.708  | 1 |
|  = 350 m s-1 | 1 |
| **Total** | **3** |

(c) Use the value from part (b) to calculate the temperature of the air in the tube. If you could not obtain an answer to part (b), use v = 342 m s-1.(2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| v(T) = 331 + 0.60T350 = 331 + 0.6T  | 1 |
| T = 31.7 °C | 1 |
| **Total** | **2** |

**Question 18** (continued)

(d) Calculate the location of the next resonance. Assume the tube is sufficiently long and ignore end error. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n = 1,3,5,7 for closed end pipes. set n = 7 | 1 |
| f7 = nv L = 7v = 7(350) or L7 = L5 + $λ/2$ 4L 4f7  4(495) = 0.874 + (0.708/2) | 1 |
|  = 1.24 m = 1.23 m | 1 |
| **Total** | **3** |

(e) If a tone of higher frequency were used, explain fully whether the resonances would occur closer together or further apart. (4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| As v= f $λ$ and v being constant: If frequency increases then $λ$ decreases | 1 |
| The distances between each successive resonant region is $λ/2$ | 1 |
| Since $λ$ decreases  | 1 |
| the distance between resonances would decrease. | 1 |
| **OR** |  |
| as fn = nv 4L | 1 |
| f $∝$ 1/L  | 1 |
| as frequency decreases, resonant length decreases  | 1 |
| meaning the distances between resonant lengths also decrease. | 1 |
| **Total** | **4** |

**End of Section 2**

**Section Three: Comprehension 12% (17 Marks)**

This section contains **One (1)** question. You must answer both questions. Write your answers in

the spaces provided. Suggested working time for this section is 40 minutes.

**Question 19** **(17 Marks)**

**Terminal Velocity**

Introductory Physics classes will often state the acceleration of objects falling near the Earth’s surface as 9.8 m s-2. While this is true in the absence of any air resistance, ignoring air resistance can lead to gross errors between theory and practical results. Objects falling through a fluid, such as Earth’s atmosphere, eventually reach a terminal velocity – the point where no further acceleration occurs.

There are three stages of falling:

1. Acceleration from rest
2. Acceleration while moving
3. Zero acceleration

When an object first starts to fall, from a resting position, there is no air resistance. The initial acceleration of the object will be 9.8 m s-2.

The object will push particles in the air out of the way as it falls. The faster the object falls, the more air it pushes out of the way each second. This is what causes air resistance. At some velocity, the acceleration of the object will be noticeably less than 9.8 m s-2 and will continue to drop as the object picks up speed.

When the object is falling fast enough, there is so much air to push out of the way that the air resistance is just as large as the gravitational force pulling the object down. This causes the acceleration of the object to drop to zero. The object then maintains this falling speed – terminal velocity has been reached.

1. The forces acting on an object falling through the atmosphere determine its acceleration. Draw a free body diagram of the physical forces acting on an object at each of its three stages of falling. Label all forces and keep all free body diagrams to the same scale.

 (5 marks)

Air resistance

Air resistance

Acceleration from rest

Zero acceleration

Acceleration while moving

Weight

Weight

Weight

Weight on all three diagrams 1

All weight vectors the same size and no additional forces (other than air resistance) 1

No air resistance/other forces on stage 1 1

Air resistance smaller than weight on stage 2, opposes weight 1

Air resistance same size as weight on stage 3, opposes weight 1

1. The velocity-time graph below shows a bowling ball falling through the atmosphere.



Stage 3

Stage 1

1. Identify and clearly label the region of the graph that shows the first stage of falling as described in the text. (1 mark)

Approx identifies linear section at start 1

1. Identify and clearly label the region of the graph that shows the third stage of falling as described in the text. (1 mark)

Approx identifies linear section at end 1

1. Using the graph in part (b), estimate the distance covered by a bowling ball in the first 4.0 s through Earth’s atmosphere. (4 marks)

$≈95 grid spaces under curve$ 1

$distance=grid spaces×value per grid space$ 1

$distance=95×\left(0.5×1\right)=48 m$ 1

Max 2 sig figs 1

Other suitable methods of estimation accepted, if changing acceleration accounted for.

1. On the graph of the bowling ball falling through the atmosphere below, sketch a theoretical velocity-time graph of a golf ball dropped at the same time as the bowling ball, ignoring air resistance. (2 marks)



Linear 1

Same gradient as initial bowling ball path/ passes through (1,9.8) 1

1. Explain why Newton’s 3rd law of motion is relevant when explaining the cause of air resistance. (4 marks)

An object moving through the air pushes air out of its way. 1

**This air pushes back** with an **equal and opposite force**, as per Newton’s 3rd law 1-2

It is the pushing back onto a object that is the cause of air resistance. 1

**End of Questions**

**Additional working space**

**End of examination**

\**Acknowledgements**

Question 20

Fig 1. Overtone spectrum of an ideal harmonic instrument

Hyacinth, CC BY-SA 3.0 <https://creativecommons.org/licenses/by-sa/3.0>, via Wikimedia Commons

Fig 2. Overtone Spectrum of a Bell

Hyacinth, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons