Student Number: _____

NORTHERN BEACHES SECONDARY COLLEGE

MANLY SELECTIVE CAMPUS

PRELIMINARY HIGHER SCHOOL CERTIFICATE

YEARLY EXAMINATION

2016

PHYSICS

General Instructions

- Reading time – 5 minutes
- Working time – 2 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Approved calculators may be used
- Write your student number in the space provided

This paper has two parts, Part A and Part B

Part A – 20 marks
- Attempt Questions 1-20
- Allow about 35 minutes for this part

Part B – 50 marks
- Attempt Questions 21-31
- Allow about 1 hour and 25 minutes for this part

Weighting: 35%

PART	TOTALS	MARKS
A	20	
B	50	
TOTAL	70	

Part A – 20 marks

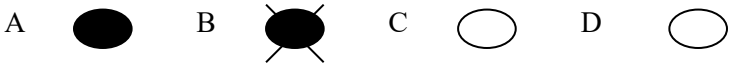
Attempt Questions 1-20
Allow about 35 minutes for this part

Use the multiple-choice answer sheet.

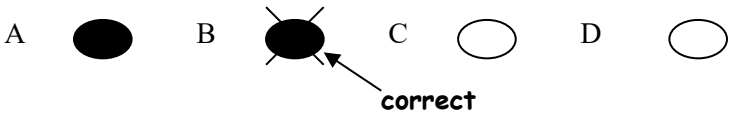
Select the alternative A,B,C or D that best answers the question. Fill in the response oval completely.

Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

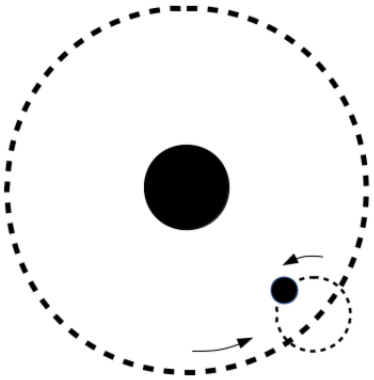
If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.



If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.



1 The diagram below shows an early model of the Solar System.



Which scientist proposed this model?

(A) Aristarchus.

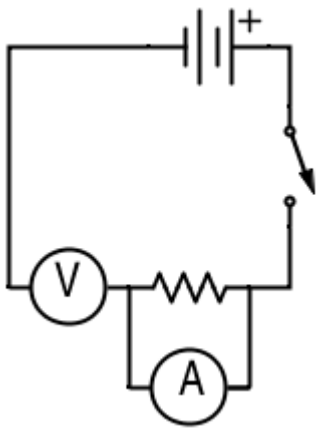
(B) Ptolemy.

(C) Copernicus.

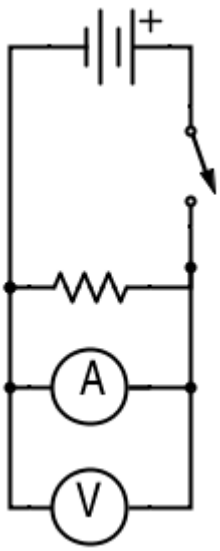
(D) Galileo.

2 Which circuit shows correct use of an ammeter and voltmeter to determine the current and voltage in the resistor?

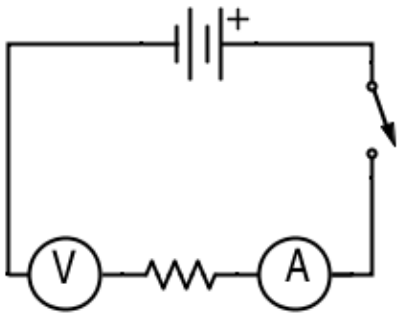
(A)



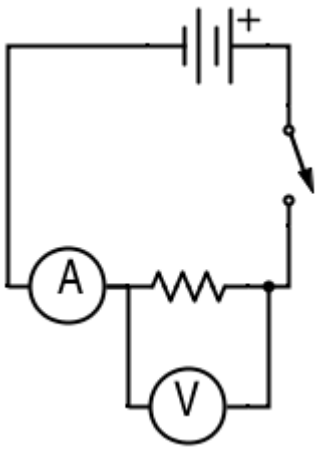
(B)



(C)

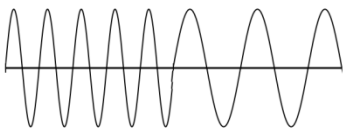


(D)

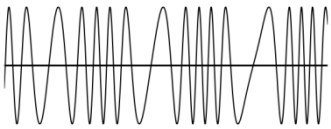


3 Which diagram shows AM modulation of a radio wave?

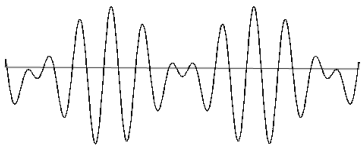
(A)



(B)



(C)



(D)

4 Which of the following is based on the superposition of two distinct waves?

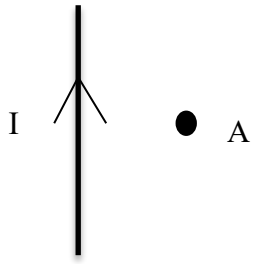
(A) FM Radio

(B) Reflection of light

(C) Refraction of light

(D) The inverse square law

5 A 5A current is flowing through a wire as shown.



If a magnaprobe (compass able to rotate in 3 dimensions) was placed at position A (marked by the dot) next to the wire, the north end of the compass would be facing:

(A) Up

(B) Down

(C) Out of the page

(D) Into the page

6 Normal household power points in Australia have 3 holes. Many devices only use two of these. How do these devices protect their users against electrical shock?

(A) Using fuses to limit the current through the device

(B) Earthing the outside case of the device

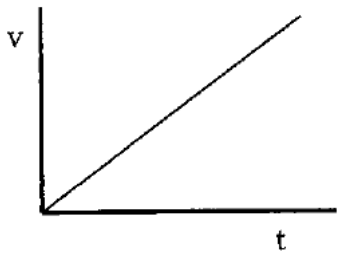
(C) Placing double insulation on all electrical components

(D) Providing circuit breakers to limit the current through the device

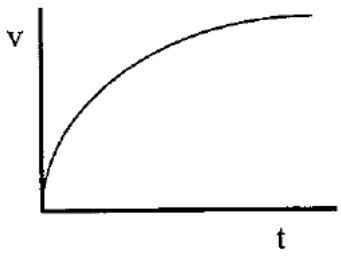
7 A car accelerates uniformly from rest on a horizontal road.

Which choice correctly shows how its velocity (v) and displacement (r) change with time?

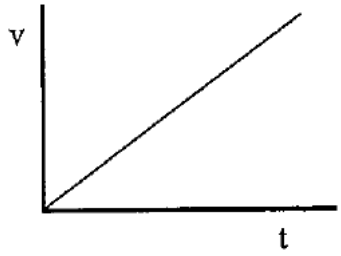
(A)



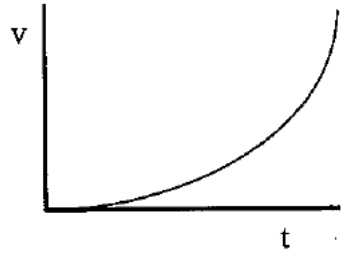
(B)



(C)



(D)



8 What is the main difference between electromagnetic (EM) waves and mechanical waves?

(A) EM waves always travel at 3 x 10^8 ms^{-1} while mechanical waves change speed depending on the medium

(B) Mechanical waves are always transverse waves while EM waves vary depending on the medium

(C) EM waves can travel without a medium while mechanical waves require a medium

(D) Mechanical waves obey the law of refraction when changing medium while EM waves display total internal reflection

9 An electron experiences a force of 8 x 10^{-16} N South when it is placed in an electric field.

What is the strength and direction of the electric field?

(A) 0.2 NC^{-1} South

(B) 0.2 NC^{-1} North

(C) 5000 NC^{-1} South

(D) 5000 NC^{-1} North

10 Which of the following can be explained by Hubble's discovery of universe expansion?

(A) The speed and acceleration of distant celestial objects outside the Milky Way as measured from Earth

(B) The motion between planets, comets and asteroids around a central star

(C) Redness or blueness of star due to the type of fusion and its expanding force

(D) The spiral movement of our galaxy

11 If 4C of charge pass through a resistor and 10J of Electrical Potential energy is dissipated, determine the Voltage across this resistor.

(A) 0.4 V

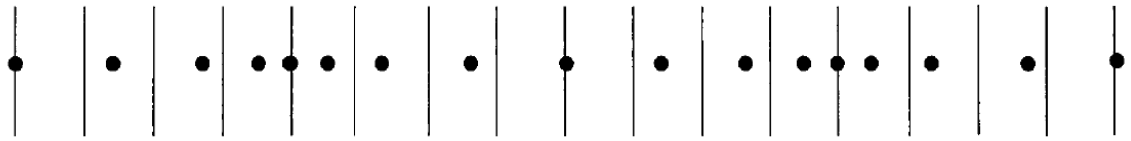
(B) 2.5 V

(C) 14 V

(D) 40 V

Use this information to answer questions 12 and 13

In the diagram of the longitudinal wave below, the particles of the medium carrying the wave are represented by black dots and rest positions of these particles by the vertical lines. The vertical lines in real life are 1×10^{-14} m apart.



12 The amplitude of this wave is closest to:

(A) Insufficient information is given to determine amplitude

(B) 0.7 cm

(C) 1.4×10^{-14} m

(D) 7×10^{-15} m

13 The frequency of this wave if it had a velocity of $330 ms^{-1}$ is closest to:

(A) 2.4×10^{-16} Hz

(B) 4.1×10^{15} Hz

(C) 3.7×10^{15} Hz

(D) 8.3×10^{15} Hz

Use the following information for Questions 14 and 15.

A dog was tied to a pole in a backyard. It was running at a constant speed in a perfect circle due to the tension of its leash.

14 In the moment when this snapshot was taken, which of the following correctly describes the direction of acceleration and momentum of the dog?

	Direction of acceleration	*Direction of momentum*
(A)	From right to left	From the pole to the dog
(B)	From left to right	From the dog to the pole
(C)	From the dog to the pole	From left to right
(D)	From the dog to the pole	From right to left

15 Which of the following changes will increase the tension on the leash the most?

(A) Shorten the leash to one-fifth of the original length and have the same dog run at the same speed

(B) Use the original leash and replace the dog with one which weighs half as much but runs twice as fast

(C) Double the length of the leash and replace the dog with one which is five times heavier but runs at the same speed

(D) Use the original leash and replace the dog with one which weighs half as much but runs three times as fast

16 Which of the following statements about refraction is INCORRECT?

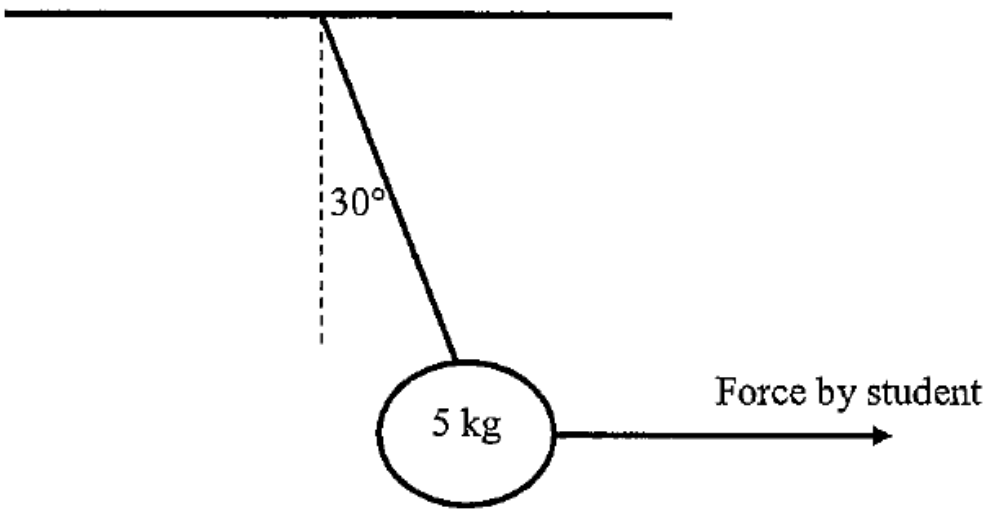
(A) For refraction to occur, there must be a speed change on the wave as it crosses the boundary between the two media

(B) The incident and refracted rays always have a different frequency, irrespective of the type of wave involved

(C) The angle between the incident ray and the normal at the boundary must be different to that made between the refracted ray and the boundary

(D) Media on each side of the boundary must have a different absolute refractive index

Use the information below and the diagram to answer questions 17 and 18



A 5 kg rock is hanging from a string tied to a hook in the ceiling. A student pulls horizontally on a second string which is tied around the rock until the supporting string makes an angle of 30° with the vertical, as shown in the diagram.

17 The weight of the bob is equal to:

(A) 0.049 N

(B) 49 N

(C) 98 N

(D) 24.5 N

18 The tension in the string and the force exerted by the student is:

	Tension in string (N)	Force exerted by student (N)
(A)	98	25
(B)	57	28
(C)	42	85
(D)	25	98

19 A student examines the properties of a copper conductor and records the following observations:

Length (m)	1.25
Diameter (m)	0.0050
Temperature (°C)	25
Resistance (Ω)	0.020

Which change is likely to result in decreasing the resistance to 0.010Ω?

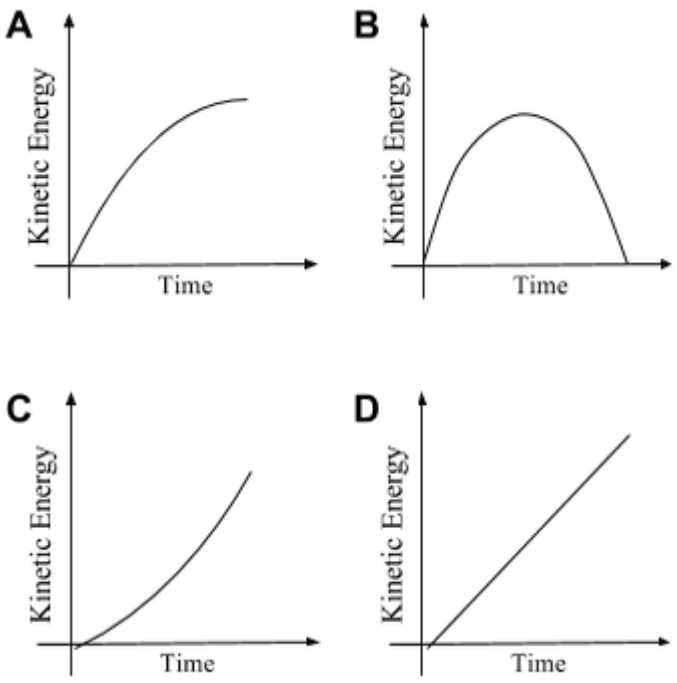
(A) Cooling the conductor to 12.5 °C

(B) Increasing the length to 2.5 m

(C) Changing the material to steel

(D) Increasing the diameter to 0.0070 m

20 Which graph represents the kinetic energy of a mass which is rolling down a smooth, inclined plane? Ignore air resistance and friction.



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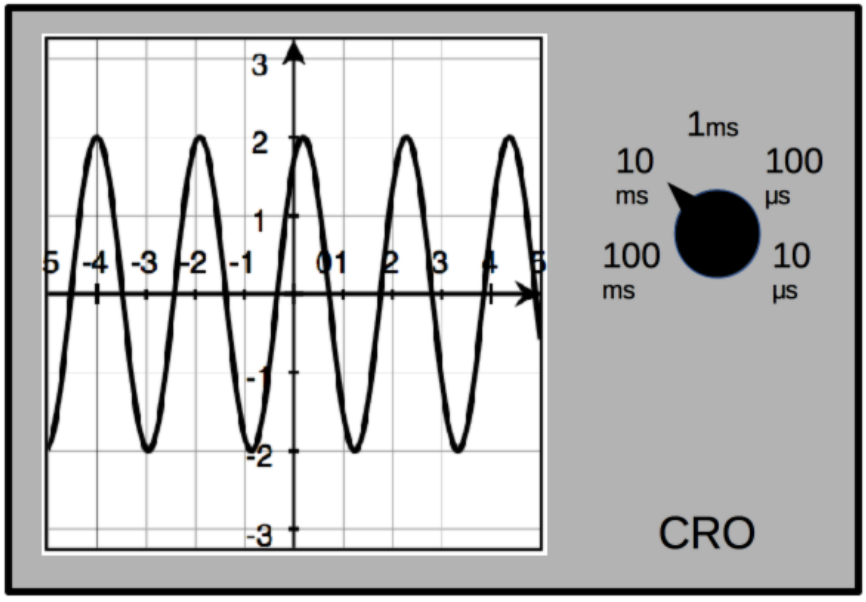
2016 PRELIMINARY SCHOOL CERTIFICATE EXAMINATION

Physics Student ID: _____

Part B – 50 marks
Attempt Questions 21–31
Allow about 1hour 25 minutes for this part
Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
Show all relevant working in questions involving calculations.

Question 21 (3 marks)

A student performs an investigation into sound waves and captures the image below.



(a) What time does each division on the X-axis represent? **1**

.....

.....

(b) What is the period of the wave being investigated? **1**

.....

.....

(c) What is the frequency of the wave being investigated? **1**

.....

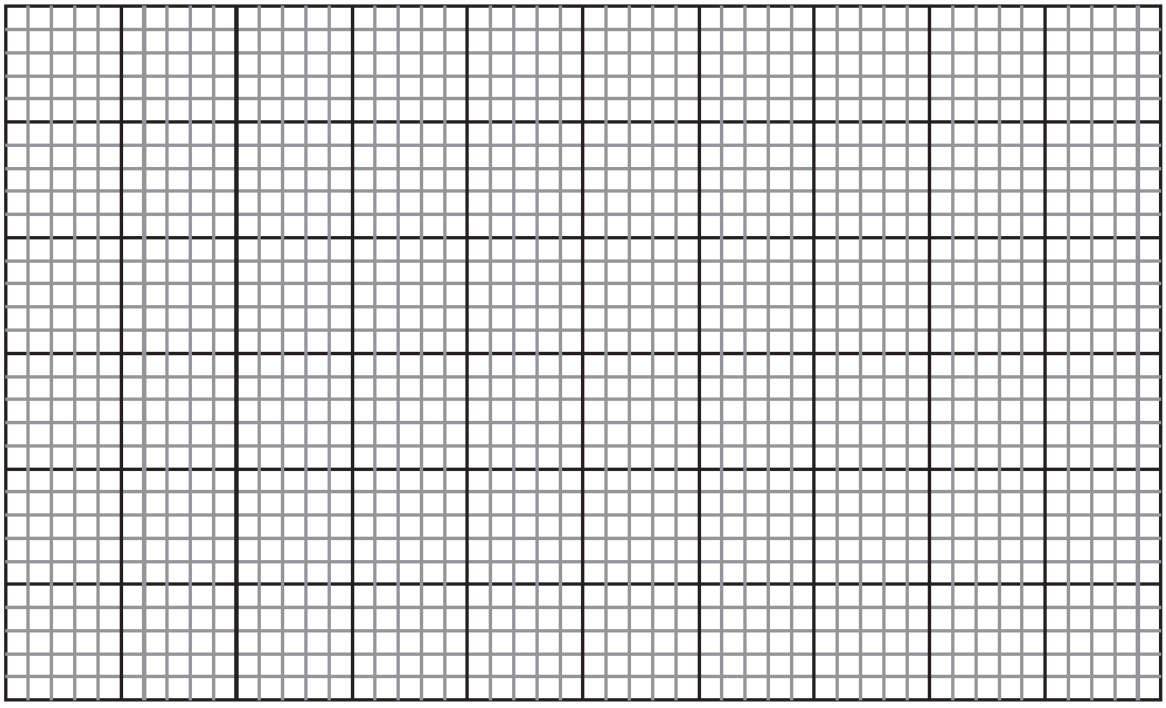
.....

Question 22 (4 marks) **Marks**

The table shows the results from an experiment where different voltages were applied across the ends of a resistance wire and the current flowing through the wire was recorded for each voltage.

Run	Applied Voltage (V)	Current flowing (A)
1	2	0.40
2	4	0.70
3	6	0.95
4	8	1.15
5	10	1.30

(a) Draw a graph of the data in the table using the graph paper below. **3**



(b) Account for the shape of the graph. **1**

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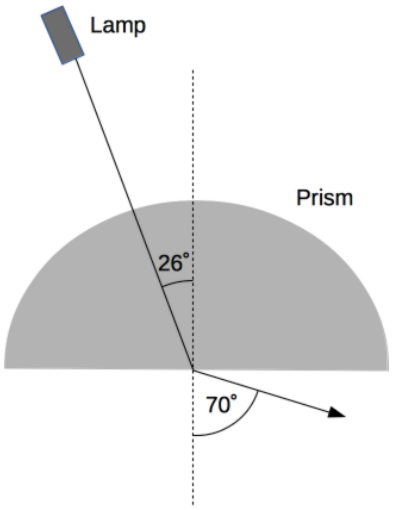
Question 23 (5 marks) **Marks**

A student is investigating the refractive index of a semi-circular prism as shown in the diagram.



(a) Identify why the ray is not refracted as it moves from the air into the prism. **1**

.....

(b) Calculate the refractive index of the material. **2**

.....

.....

(c) Determine the critical angle for this material. **2**

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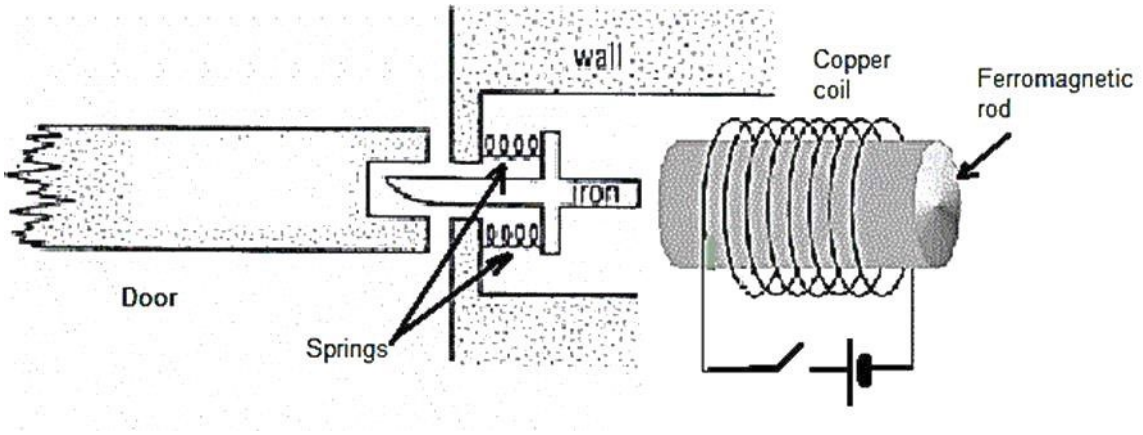
.....

Question 24 (4 marks)



(a) In the diagram above, sketch the magnetic field lines produced by the electromagnet when it is switched on. **2**

(b) Explain how the electromagnetic lock would work with the opening and closing of the switch. **2**

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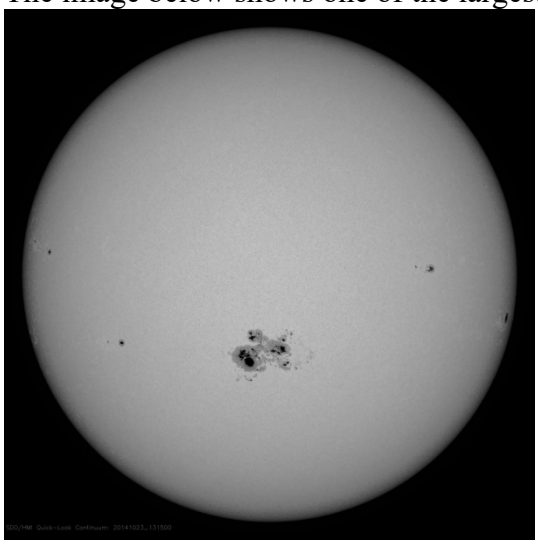
Question 25 (5 marks)

The image below shows one of the largest sunspots ever recorded.



(Adapted from an original NASA image at https://www.flickr.com/photos/gsfc/15430820129, Creative Commons licensed: https://creativecommons.org/licenses/by/2.0/)

(a) Identify two characteristics of sunspots other than their luminosity **2**

(b) Discuss the effects of sunspot activity on the Earth's power grid and satellite communications. **3**

Question 26 (6 marks)

During the final phase of sending the *Curiosity* to land on Mars, NASA stated that it took a radio signal 12 minutes and 50 seconds to reach the descending rover.

(a) Calculate the distance between the *Curiosity* and Ground Control at NASA on Earth in the final phase. **2**

(b) The *Curiosity* transmits its signal in an X-band (8.00–12.00 GHz) radio wave. **2**

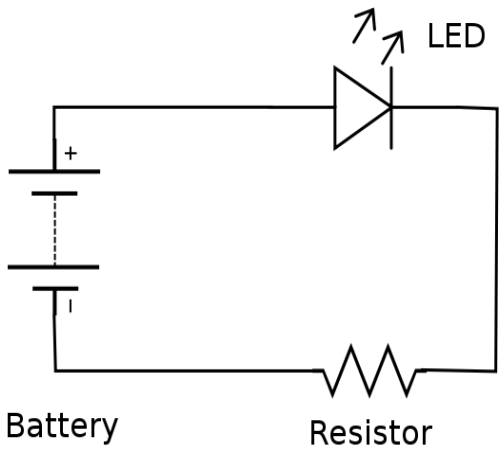
Determine the range of wavelength of these signals.

(d) Some planets like Mars have a weak or absent ionosphere compared to Earth. **2**

Describe ONE possible impact of this upon long-range radio communication between two points on the surface of such planets.

Question 27 (6 marks)

One main role of resistors in a circuit is to limit voltage across other electrical components. This is shown in the example below.



(a) The LED is running at 25 mA and 3.2 V. **2**

Determine the resistor's resistance if the battery produces 5V.

(b) Determine the total power of the circuit. **2**

(c) A student uses a large white plastic box as cover. He places a photometer 5.00 mm from the LED and it reads 895 lux. **2**

What would be the reading of the photometer when it is 15.00 mm from the LED?

Question 28 (6 marks)

An airplane is 30 km south of the airport where it must land in 7 minutes (i.e. the velocity the plane must fly relative to the ground is 257 km/h). There is a strong wind blowing from the west at 50 km/h.

(b) Use a vector diagram to determine the velocity at which the plane needs to fly relative to the air in order to land at the airport. **3**

(c) Explain why the plane can appear to violate Newton's First Law by applying a constant thrust and maintaining a constant velocity. **2**

Question 29 (5 marks)

Abi rolls a bowling ball down a smooth 18.288 m lane at a constant speed of 5.50 m/s in a straight line.

(a) Brian, her naughty little brother, rolls another bowling ball at constant speed, moments after Abi's, in the same lane at a speed of 6.00 m/s. Brian's ball catches up and collides with his sister's 0.75 m before the end of the lane. **2**

Determine how much later Brian released his ball.

(b) After the collision, Abi's ball increases its speed by 20% and Brian's ball moves backwards at 1.00 m/s. **3**

Is it fair for Brian to claim his ball is heavier than Abi's? Justify your response.

Question 30 (3 marks)

Use the information in the image and table of Spectral classes.

TABLE 15.1 The Spectral Sequence

Spectral Type	Example(s)	Temperature Range
O	Stars of Orion's Belt	>30,000 K
B	Rigel	30,000 K–10,000 K
A	Sirius	10,000 K–7500 K
F	Polaris	7500 K–6000 K
G	Sun, Alpha Centauri A	6000 K–5000 K
K	Arcturus	5000 K–3500 K
M	Betelgeuse, Proxima Centauri	<3500 K

Star name	*Spectral class*
Acrux	B
Mimosa	B
Gacrux	M
δ Cru	B
ε Cru	K
The Sun	G

Between Acrux and δ Cru, which star is closer to Earth? Justify your response. **3**

Question 31 (4 marks)

Explain how either seatbelts or airbags work to protect the occupants of a car in a collision. **4**

Refer to both concepts of impulse and momentum in your answer.

End of paper

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2016 PRELIMINARY EXAMINATION

Physics

DATA SHEET

Charge on electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	340 ms^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Speed of light, c	3.00×10^{8} m s^{-1}
Magnetic force constant,	2.0×10^{-7} N A^{-2}
Universal gravitational constant, G	6.67×10^{-11} N m^2 kg^{-2}
Mass of Earth	6.0×10^{24} kg
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	1.097×10^{7} m^{-1}
Atomic mass unit, u	1.661×10^{-27} kg 931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, ρ	1.00×10^{3} kg m^{-3}
Specific heat capacity of water	4.18×10^{3} J kg^{-1} K^{-1}

FORMULAE SHEET

$$v = f\lambda$$

$$I \propto \frac{1}{d^2}$$

$$\frac{v_1}{v_2} = \frac{\sin i}{\sin r}$$

$$E = \frac{F}{q}$$

$$R = \frac{V}{I}$$

$$P = VI$$

$$\text{Energy} = VIt$$

$$v_{av} = \frac{\Delta r}{\Delta t}$$

$$a_{av} = \frac{\Delta v}{\Delta t} \text{ therefore } a_{av} = \frac{v-u}{t}$$

$$\Sigma F = ma$$

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

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

$$W = Fs$$

$$p = mv$$

$$\text{Impulse} = Ft$$

$$E_p = -G\frac{m_1 m_2}{r}$$

$$F = mg$$

$$v_x^2 = u_x^2$$

$$v = u + at$$

$$v_y^2 = u_y^2 + 2a_y\Delta y$$

$$\Delta x = u_x t$$

$$\Delta y = u_y t + \frac{1}{2}a_y t^2$$

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

$$F = \frac{Gm_1 m_2}{d^2}$$

$$E = mc^2$$

$$l_v = l_0\sqrt{1-\frac{v^2}{c^2}}$$

$$t_v = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$m_v = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

FORMULAE SHEET

$$\frac{F}{l} = k\frac{I_1 I_2}{d}$$

$$F = BIl\sin\theta$$

$$\tau = Fd$$

$$\tau = nBIA\cos\theta$$

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

$$d = \frac{1}{p}$$

$$M = m - 5\log\left(\frac{d}{10}\right)$$

$$\frac{I_A}{I_B} = 100^{(m_B - m_A)/5}$$

$$m_1 + m_2 = \frac{4\pi^2 r^3}{GT^2}$$

$$F = qvB\sin\theta$$

$$E = \frac{V}{d}$$

$$E = hf$$

$$c = f\lambda$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\lambda = \frac{h}{mv}$$

$$Z = \rho v$$

$$\frac{I_r}{I_0} = \frac{\left[Z_2 - Z_1\right]^2}{\left[Z_2 + Z_1\right]^2}$$

$$A_0 = \frac{V_{\text{out}}}{V_{\text{in}}}$$

$$\frac{V_{\text{out}}}{V_{\text{in}}} = -\frac{R_{\text{f}}}{R_{\text{i}}}$$

Student Number: _____

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic number	
Chemical symbol	
Relative atomic mass	
Name of element	

1 **H** 1.008 Hydrogen																	2 **He** 4.003 Helium
3 **Li** 6.941 Lithium	4 **Be** 9.012 Beryllium											5 **B** 10.81 Boron	6 **C** 12.01 Carbon	7 **N** 14.01 Nitrogen	8 **O** 16.00 Oxygen	9 **F** 19.00 Fluorine	10 **Ne** 20.18 Neon
11 **Na** 22.99 Sodium	12 **Mg** 24.31 Magnesium											13 **Al** 26.98 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.97 Phosphorus	16 **S** 32.07 Sulfur	17 **Cl** 35.45 Chlorine	18 **Ar** 39.95 Argon
19 **K** 39.10 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.87 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.55 Copper	30 **Zn** 65.38 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 72.64 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 Selenium	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypton
37 **Rb** 85.47 Rubidium	38 **Sr** 87.61 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.96 Molybdenum	43 **Tc** Technetium	44 **Ru** 101.1 Ruthenium	45 **Rh** 102.9 Rhodium	46 **Pd** 106.4 Palladium	47 **Ag** 107.9 Silver	48 **Cd** 112.4 Cadmium	49 **In** 114.8 Indium	50 **Sn** 118.7 Tin	51 **Sb** 121.8 Antimony	52 **Te** 127.6 Tellurium	53 **I** 126.9 Iodine	54 **Xe** 131.3 Xenon
55 **Cs** 132.9 Caesium	56 **Ba** 137.3 Barium	Lanthanoids 57-71 * -	72 **Hf** 178.5 Hafnium	73 **Ta** 180.9 Tantalum	74 **W** 183.9 Tungsten	75 **Re** 186.2 Rhenium	76 **Os** 190.2 Osmium	77 **Ir** 192.2 Iridium	78 **Pt** 195.1 Platinum	79 **Au** 197.0 Gold	80 **Hg** 200.6 Mercury	81 **Tl** 204.4 Thallium	82 **Pb** 207.2 Lead	83 **Bi** 209.0 Bismuth	84 **Po** Polonium	85 **At** Astatine	86 **Rn** Radon
87 **Fr** Francium	88 **Ra** Radium	Actinoids 89-103 ** -	104 **Rf** Rutherfordium	105 **Db** Dubnium	106 **Sg** Seaborgium	107 **Bh** Bohrium	108 **Hs** Hassium	109 **Mt** Meitnerium	110 **Ds** Darmstadtium	111 **Rg** Roentgenium	112 **Cn** Copernicium						

***Lanthanoids**

57 **La** 138.9 Lanthanum	58 **Ce** 140.1 Cerium	59 **Pr** 140.9 Praseodymium	60 **Nd** 144.2 Neodymium	61 **Pm** Promethium	62 **Sm** 150.4 Samarium	63 **Eu** 152.0 Europium	64 **Gd** 157.3 Gadolinium	65 **Tb** 158.9 Terbium	66 **Dy** 162.5 Dysprosium	67 **Ho** 164.9 Holmium	68 **Er** 167.3 Erbium	69 **Tm** 168.9 Thulium	70 **Yb** 173.1 Ytterbium	71 **Lu** 175.0 Lutetium

****Actinoids**

89 **Ac** Actinium	90 **Th** 232.0 Thorium	91 **Pa** 231.0 Protactinium	92 **U** 238.0 Uranium	93 **Np** Neptunium	94 **Pu** Plutonium	95 **Am** Americium	96 **Cm** Curium	97 **Bk** Berkelium	98 **Cf** Californium	99 **Es** Einsteinium	100 **Fm** Fermium	101 **Md** Mendelevium	102 **No** Nobelium	103 **Lr** Lawrencium

Elements with atomic numbers 113 and above have been reported but not fully authenticated.
Standard atomic weights are abridged to four significant figures.
Elements with no reported values in the table have no stable nuclides.

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2016 YEAR 11 PRELIMINARY YEARLY EXAMINATION
PHYSICS– MULTIPLE CHOICE ANSWER SHEET

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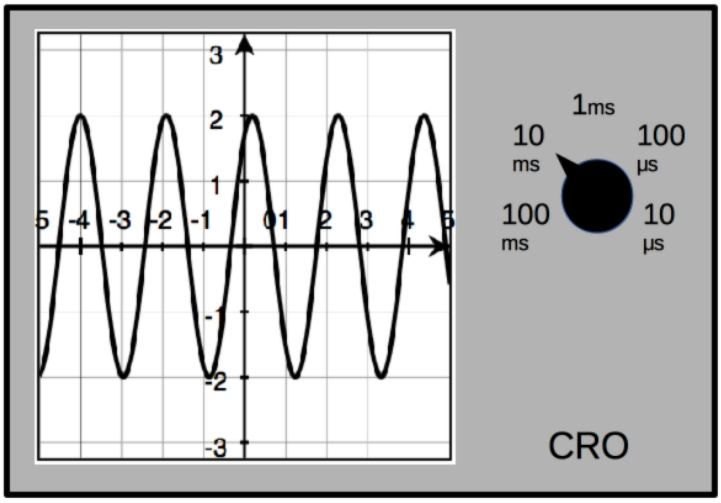
14.	A ⬭	B ⬭	C ⬭	D ⬭
15.	A ⬭	B ⬭	C ⬭	D ⬭
16.	A ⬭	B ⬭	C ⬭	D ⬭
17.	A ⬭	B ⬭	C ⬭	D ⬭
18.	A ⬭	B ⬭	C ⬭	D ⬭
19.	A ⬭	B ⬭	C ⬭	D ⬭
20.	A ⬭	B ⬭	C ⬭	D ⬭

Physics Preliminary Examination Marking Guidelines

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
B	D	C	A	D	C	A	C	D	A	B	D	B	D	A	B	B	B	D	C

Question 21 (3 marks)

A student performs an investigation into sound waves and captures the image below.



(a) What time does each division on the X-axis represent?

Marking Guidelines	Marks
• Correctly identifies 10ms (units required)	1

(b) What is the period of the wave being investigated?

Marking Guidelines	Marks
• Identifies 21ms ± 1ms (units required)	1

(c) What is the frequency of the wave being investigated?

$$f = \frac{1}{T}$$
$$f = \frac{1}{21 \times 10^{-3}}$$
$$f = 46.7\ Hz$$

Marking Guidelines	Marks
• Calculates 46.7 Hz (units not required)	1

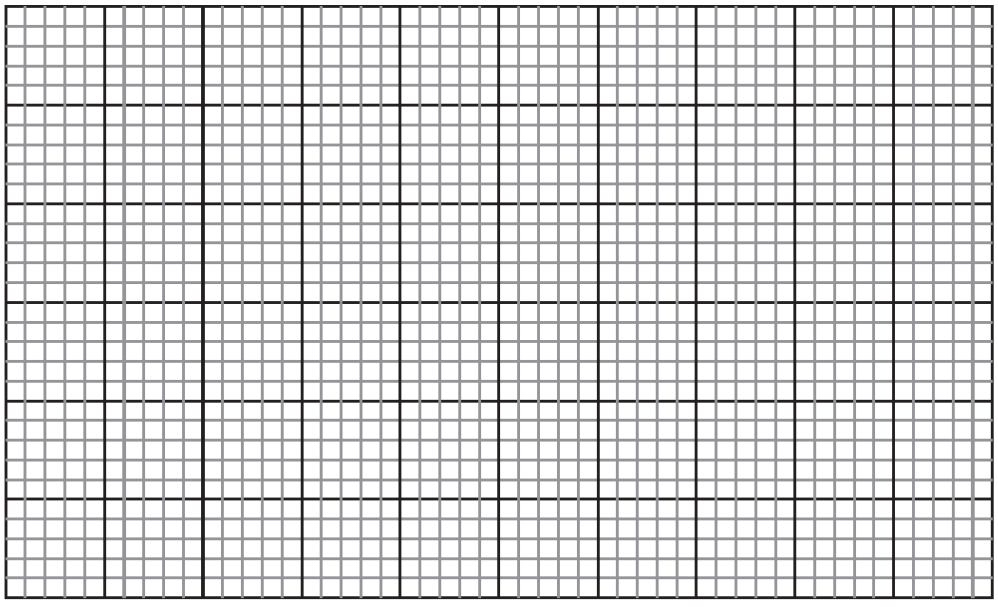
Question 22 (4 marks) **Marks**

The table shows the results from an experiment where different voltages were applied across the ends of a resistance wire and the current flowing through the wire was recorded for each voltage.

Run	Applied Voltage (V)	Current flowing (A)
1	2	0.40
2	4	0.70
3	6	0.95
4	8	1.15
5	10	1.30

(a) Draw a graph of the data in the table using the graph paper below. **3**

Marking Guidelines	**Marks**
• Correctly plots points • Draws a curve of best fit • Axes correctly labelled with units and even scale (independent of V vs I or I vs V)	**3**
• Any number of the above	**1-2**

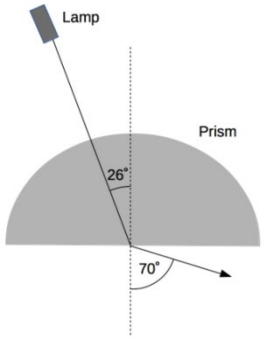


(b) Account for the shape of the graph. **1**

Marking Guidelines	**Marks**
• Shows cause relationship between resistance and curve	**1**

Question 23 (5 marks) **Marks**

A student is investigating the refractive index of a semi-circular prism as shown in the diagram.



(a) Identify why the ray is not refracted as it moves from the air into the prism.

Marking Guidelines	Marks
• Identifies the incident ray is perpendicular to surface (or lies along normal line)	**1**

(b) Calculate the refractive index of the material.

$$\frac{sini}{sinr} = \frac{n_2}{n_1}$$
$$\frac{sin26}{sin70} = \frac{1.00}{n_1}$$
$$n_1 = 2.14$$

Marking Guidelines	Marks
• Calculates refractive index correctly • Shows working using Snell's law	**2**
• Shows an application of Snell's law OR • Determines answer without showing working	**1**

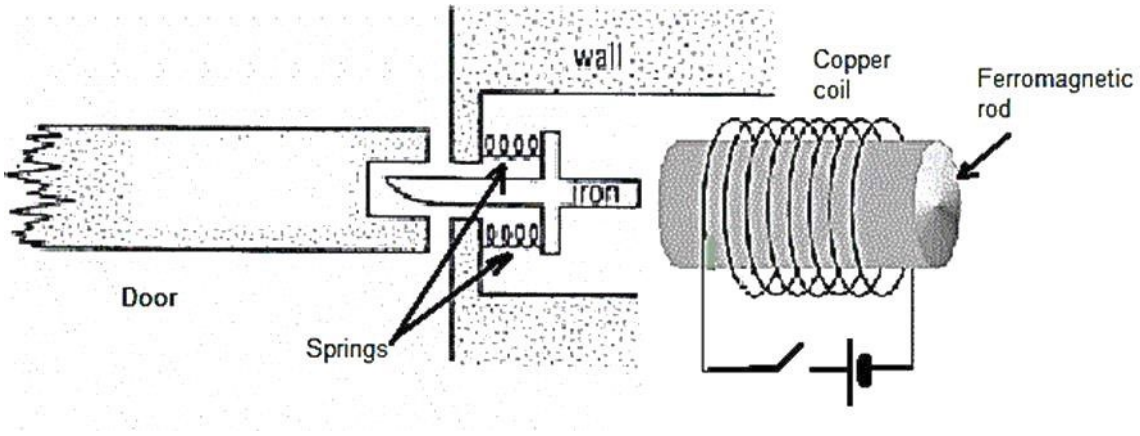
2

(c) Determine the critical angle for this material.

$$\frac{sini_c}{sin90} = \frac{n_2}{n_1}$$
$$\frac{sini_c}{sin90} = \frac{1.00}{2.14}$$
$$i_c = 28°$$

Marking Guidelines	Marks
• Calculates critical angle correctly • Shows complete working using Snell's law (fully substituted equation shown)	**2**
• Identifies refracted angle = 90° OR • Determines correct answer without showing working	**1**

Question 24 (4 marks)



(a) In the diagram above, sketch the magnetic field lines produced by the electromagnet when it is switched on. **2**

Marking Guidelines	Marks
• Successfully indicates the profile, relative strength (spacing between field lines) and direction of the magnetic field	**2**
• Draws a magnetic field around the solenoid with incorrect direction OR • Draws correct direction of field but has field lines crossing or incorrectly drawn	**1**

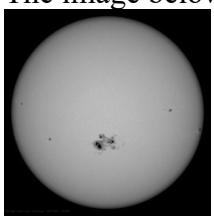
(b) Explain how the electromagnetic lock would work with the opening of the switch. **2**

Marking Guidelines	Marks
• Explains that when the switch is open, current will no longer flow through the electromagnet and not produce a magnetic field • Identifies will no longer be magnetised and the spring will force it back into the door to lock.	**2**
• Shows an understanding of the attractive force between electromagnet and iron to unlock door OR • Explains the situation when the switch is closed only	**1**

Sample Answer:
When the switch is open, current no longer flows through the coil and the associated magnetic field no longer forms a net dipole. The magnetic moments in iron will no longer be aligned to this field and not be attracted to the electromagnet. The spring pulls the lock back into position, locking the door.

Question 25 (5 marks)

The image below shows one of the largest sunspots ever recorded.



(Adapted from an original NASA image at https://www.flickr.com/photos/gsfc/15430820129, Creative Commons licensed: https://creativecommons.org/licenses/by/2.0/)

(a) Identify two characteristics of sunspots other than their luminosity **2**

Marking Guidelines	Marks
• Identifies 2 characteristics	**2**
• Identifies 1 characteristic	**1**

Any two of
- 1000K cooler than surrounding regions (or identifies significantly cooler than surrounding region)
- Form in pairs
- Move over the surface

'Dark or black' not accepted as this is related to luminosity

(b) Discuss the effects of sunspot activity on the Earth's power grid and satellite communications. **3**

Marking Guidelines	Marks
• Clearly discusses at least two effects of sunspot activity on Earth's power grid and satellite communication	**3**
• Outlines two effects OR describes one effect of sunspot activity with great detail	**2**
• Outlines one effect of sunspot activity	**1**

Sunspots are associated with significant increases in the intensity of the solar wind. The charged particles in the solar wind can have negative impacts on both the power grid and satellite communication.
Charged particles in the solar wind can induce large currents in the power grid that can damage transformers and switching equipment, as well as any attached appliances. These currents may even present a hazard to humans in severe solar storms. These effects are therefore a major problem for human society.
Charged particles can also induce currents in satellites, which can damage them. The particles also interact with the ionosphere, which can limit the ability to send radio signals to and from satellites. This means increased solar winds as a result of sunspots can cause significant degradation to satellite communication.

Question 26 (6 marks)

During the final phase of sending the *Curiosity* to land on Mars, NASA stated that it took a radio signal 12 minutes and 50 seconds to reach the descending rover.

(a) Calculate the distance between the *Curiosity* and Ground Control at NASA on Earth in the final phase. **2**

Criteria	Marks
• Successfully determines the distance with appropriate SF	2
• Applies some form of distance, time and speed relationship	1

Suggested answer:
$d=(12X60+50)X3X10^{8} = 2.31X10^{11}m = 231$ million m

(b) The *Curiosity* transmits its signal in an X-band (8.00–12.00 GHz) radio wave. **2**

Determine the range of wavelength of these signals.

Criteria	Marks
• Successfully determines the range of wavelength with appropriate working and units	2
• Applies some form of velocity, frequency and wavelength relationship OR • Only determines the lower or upper bound of wavelength	1

Suggested answer:
Upper bound: $= v/f = 3X10^{8} / 8 X 10^{9} = 0.0375m$
Lower bound: $= v/f = 3X10^{8} / 12 X 10^{9} = 0.0250m$

(d) Some planets like Mars have a weak or absent ionosphere compared to Earth. **2**

Describe ONE possible impact of this upon long-range radio communication between two points on the surface of such planets.

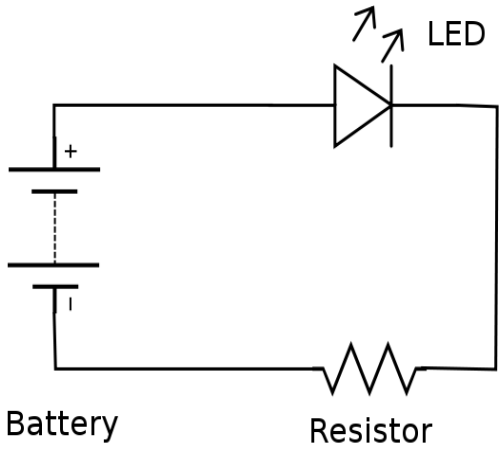
Criteria	Marks
• Identifies the role of ionosphere in radio communication and explains the potential consequences	2
• Identifies the role of ionosphere in radio communication OR • Shows cause and effect relationship with incorrect assumption	1

Suggested answer:
The ionosphere has the ability to reflect some of the radio signal directed to the sky back to the ground. This results in the radio wave reaching places that are not in the line of sight due to either obstacles or curvature of the horizon as distance increases. The lack of an ionosphere would effectively reduce the transmission range of ground-based radio transmission.

Note:
Radio waves are interfered with by similar wavelengths, not Xrays and gamma rays. Also, the ionosphere is charged because of incident radiation (careful of cause and effect relationships).

Question 27 (6 marks)

One main role of resistors in a circuit is to limit voltage across other electrical components. This is shown in the example below.



(a) The LED is running at 25 mA and 3.2 V. **2**

Determine the resistor's resistance if the battery produces 5V.

Criteria	Marks
• Substitutes and calculates correct value	2
• Demonstrates the use of Ohm's law	1

Suggested answer:
Voltage across resistor is 5-3.2=1.8V
Since V=IXR, R=V/I
$=1.8/25X10^{-3}$ $=72\ \Omega$

(b) Determine the total power of the circuit. **2**

Criteria	Marks
• Determines the power usage of one of the components OR arithmetic error but with correct approach	2
• Demonstrates the use of P=IV or $P=I^2R$	1

Suggested answer:

$$P_{LED} = VI$$
$$P_{LED} = 3.2 \times 25 \times 10^{-3}$$
$$P_{circuit} = 0.08\ W$$

$$P_{Resistor} = I^2R$$
$$P_{resistor} = (25 \times 10^{-3})^2 \times 72$$
$$P_{circuit} = 0.045\ W$$

Total Power = 0.08 + 0.045 = 0.125W
OR JUST

$$P_{circuit} = VI$$
$$P_{circuit} = 5 \times 25 \times 10^{-3}$$
$$P_{circuit} = 0.125\ W$$

(c) A student uses a large white plastic box as cover. He places a photometer 5.00 mm from the LED and it reads 895 lux. **2**

What would be the reading of the photometer when it is 15.00 mm from the LED?

Criteria	Marks
• Substitutes and calculates correct value with appropriate SF	2
• Demonstrate the use of inverse square law	1

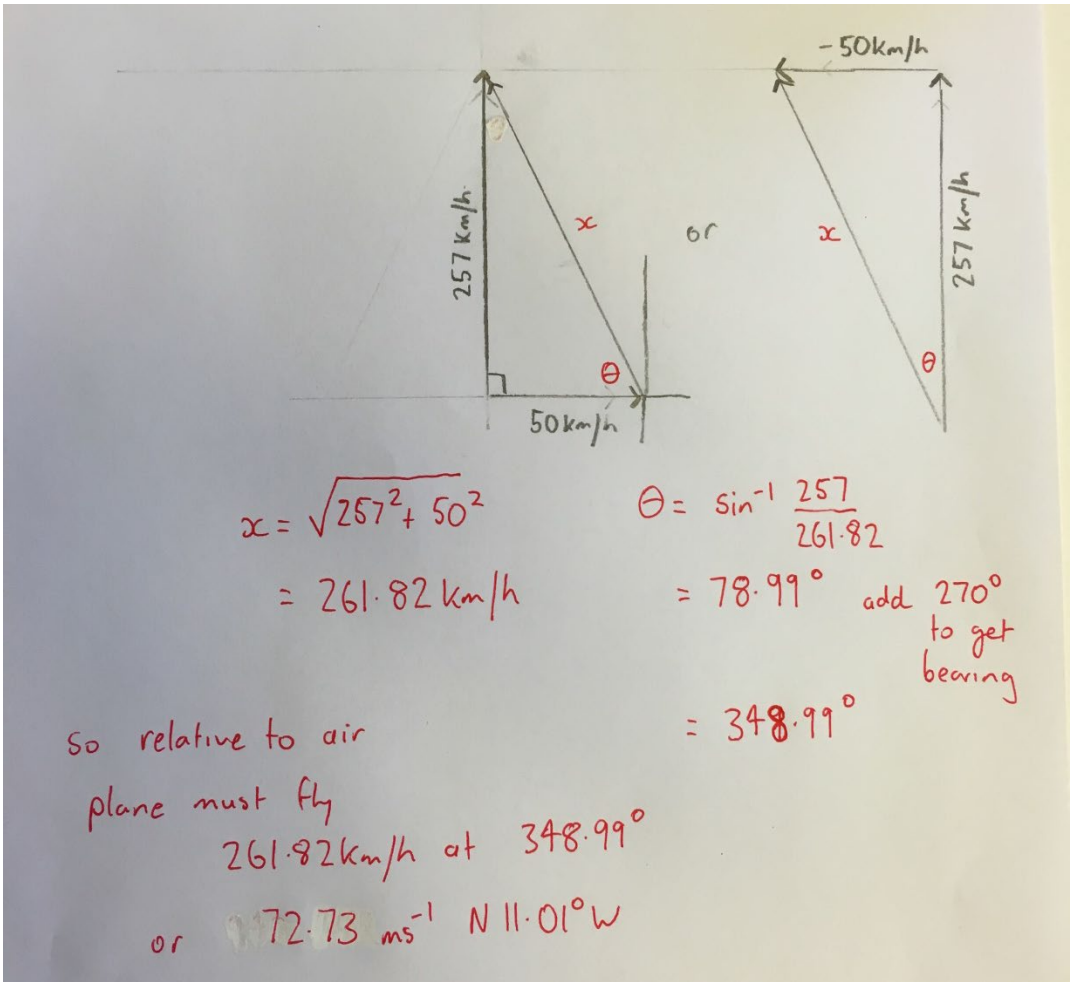
Suggested answer:
$895/3^2 = 99.6 = 99.6$ lux

Question 28 (6 marks)

An airplane is 30 km south of the airport where it must land in 7 minutes (i.e. the velocity the plane must fly relative to the ground is 257 km/h). There is a strong wind blowing from the west at 50 km/h.

(a) Use a vector diagram to determine the velocity at which the plane needs to fly relative to the air in order to land at the airport. **3**

Criteria	Marks
• Draws appropriate vector diagram AND provides correct velocity (including direction)	3
• Draws appropriate vector diagram OR provides correct velocity (including direction)	2
• Draws an appropriate vector diagram OR provides correct speed OR correct direction	1



(b) Explain why the plane can appear to violate Newton's First Law by applying a constant thrust and maintaining a constant velocity. **2**

Criteria	Marks
• Explains that air resistance balances thrust to provide zero net force, and therefore constant velocity • Relates to Newton's 1st Law	2
• Identifies air resistance OR identifies that net force is zero	1

Sample answer

This appears to violate Newton's 1st law as it appears a thrust force is being applied but a constant velocity is maintained. Newton's law is upheld when air resistance is considered i.e. the plane will accelerate until air resistance balances the forward thrust. At this speed the net force is zero, so the acceleration is zero and the plane maintains constant velocity.

Question 29 (5 marks)

Abi rolls a bowling ball down a smooth 18.288 m lane at a constant speed of 5.50 m/s in a straight line.

(a) Brian, her naughty little brother, rolls another bowling ball at constant speed, moments after Abi's, in the same lane at a speed of 6.00 m/s. Brian's ball catches up and collides with his sister's 0.75 m before the end of the lane. **2**

Determine how much later Brian released his ball.

Criteria	Marks
• Correctly calculates the time delay	2
• Provides some determination of time taken to catch up or relevant and meaningful approach	1

Suggested answer:
Distance = 18.288-0.75 = 17.538
Time taken by Abi's ball to point of taking over = 17.538/5.5 = 3.18872s
Time required by Brian's ball to reach point of taking over=17.538/6.0 = 2.9230s
Difference between the two balls is 0.266s so Brian's ball was released 0.266s later.

(b) After the collision, Abi's ball increases its speed by 20% and Brian's ball moves backwards at 1.00 m/s. **3**

Is it fair for Brian to claim his ball is heavier than Abi's? Justify your response.

Criteria	Marks
• Determines the ratio of mass and uses it to disprove Brian's claim	3
• Constructs a response that justifies the statement and which applies conservation of momentum or other relevant laws but did not find a definitive ratio between the two mass	2
• Makes some determination of momentum or gives some relevant information	1

According conservation of momentum:
$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$
m_1 being Abi's and m_2 being Brian's
Since Abi's ball increases its speed by 20%
$M_1u_1 + m_2u_2 = 1.2m_1u_1 + m_2v_2$
$-0.2m_1u_1 = m_2 (v_2-u_2)$
Now sub in velocity
$-1.1m_1=-7m_2$
$m_2/m_1 = 1.1/7$

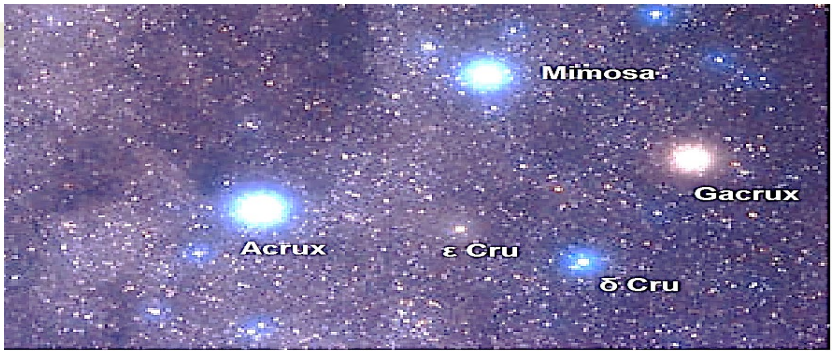
Therefore, m_2 must be lighter than m_1, Hence, Brian's claim is invalid.

Question 30 (3 marks)

Use the information in the image and table of Spectral classes.

TABLE 15.1 The Spectral Sequence

Spectral Type	Example(s)	Temperature Range
O	Stars of Orion's Belt	>30,000 K
B	Rigel	30,000 K–10,000 K
A	Sirius	10,000 K–7500 K
F	Polaris	7500 K–6000 K
G	Sun, Alpha Centauri A	6000 K–5000 K
K	Arcturus	5000 K–3500 K
M	Betelgeuse, Proxima Centauri	<3500 K



Star name	*Spectral class*
Acrux	B
Mimosa	B
Gacrux	M
δ Cru	B
ε Cru	K
The Sun	G

Between Acrux and δ Cru, which star is closer to Earth? Justify your response. **3**

Criteria	**Marks**
• Identifies that colour correlates to luminosity and the apparent difference must be due to difference in distance	3
• Correctly identifies which star is closer AND • Provides partial explanation of the relationship between brightness, luminosity and surface temperature	2
• Correctly identifies which star is closer	1

Both Acrux and δ Cru are in spectral class B so have relatively similar surface temperatures. Assuming they are also the same type of stars (e.g. large mass main sequence stars) they would have similar luminosities. From the image, and their relative brightness it would be deduced that Acrux is closer as the intensity of the star is greater in the image and $I\alpha\ 1/d^2$ with increasing distance reducing the intensity observed.

Question 31 (4 marks)

Explain how either seatbelts or airbags work to protect the occupants of a car in a collision. **4**

Refer to both concepts of impulse and momentum in your answer.

Criteria	Marks
• Notes that impulse is fixed in a collision • Outlines that airbags/seatbelts increase the time a change in momentum is experienced • Applies impulse = $Ft = \Delta\rho$ to explain that the force is reduced • Implies/outlines that reduced force results in reduced injury/reduced acceleration of the body	4
• 2 or 3 of the above	3-2
• Shows a limited understanding of momentum/impulse as they apply to a car collision	1

Notes:
Many responses showed confusion about correct usage of the term impulse.
The question asks for either seatbelts or airbags so only the first was marked if more than one was answered
Although knowledge of aspects was good, the logic and the sequencing of the argument was poor and often contradictory

Sample answer
In a collision, a change in momentum is experienced over a very short period of time, leading to a large force experienced due to $Ft = \Delta\rho$. Seatbelts act to restrain a passenger in a collision such that they experience the same deceleration as the car as oppose to following Newton's 1st law and having a collision with the windscreen (i.e. a very short time). They also have a bit of stretch to ensure the change in momentum is experienced over the longest time possible Since the change in momentum in a collision is fixed for a given velocity, an increase in time results in a proportional decrease in force on the passenger thus they are less likely to be injured.

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4.	A ⬭	B ⬭	C ⬭	D ⬭
5.	A ⬭	B ⬭	C ⬭	D ⬭
6.	A ⬭	B ⬭	C ⬭	D ⬭
7.	A ⬭	B ⬭	C ⬭	D ⬭
8.	A ⬭	B ⬭	C ⬭	D ⬭
9.	A ⬭	B ⬭	C ⬭	D ⬭
10.	A ⬭	B ⬭	C ⬭	D ⬭
11.	A ⬭	B ⬭	C ⬭	D ⬭
12.	A ⬭	B ⬭	C ⬭	D ⬭
13.	A ⬭	B ⬭	C ⬭	D ⬭
14.	A ⬭	B ⬭	C ⬭	D ⬭
15.	A ⬭	B ⬭	C ⬭	D ⬭

16. A ⬭ B ⬭ C ⬭ D ⬭

17. A ⬭ B ⬭ C ⬭ D ⬭

18. A ⬭ B ⬭ C ⬭ D ⬭

19. A ⬭ B ⬭ C ⬭ D ⬭

20. A ⬭ B ⬭ C ⬭ D ⬭