STUDENT NUMBER: _____

North Sydney Boys High School
Year 12 Physics 2022
Trial HSC Examination

General Instructions

- Reading time – 5 minutes
- Working time – 135 minutes
- Board approved calculators may be used
- Write using black pen
- Write your student number at the top of every separated page
- Use the multiple-choice answer sheet provided at the end by separating it
- A NESA data and formula sheet is provided at the end and can be separated

Total Marks – 75

Part A - 16 marks

- Attempt Questions 1–16
- Allow about 20 minutes for this part

Part B - 59 marks

- Attempt Questions 17–24
- Allow about 115 minutes for this part

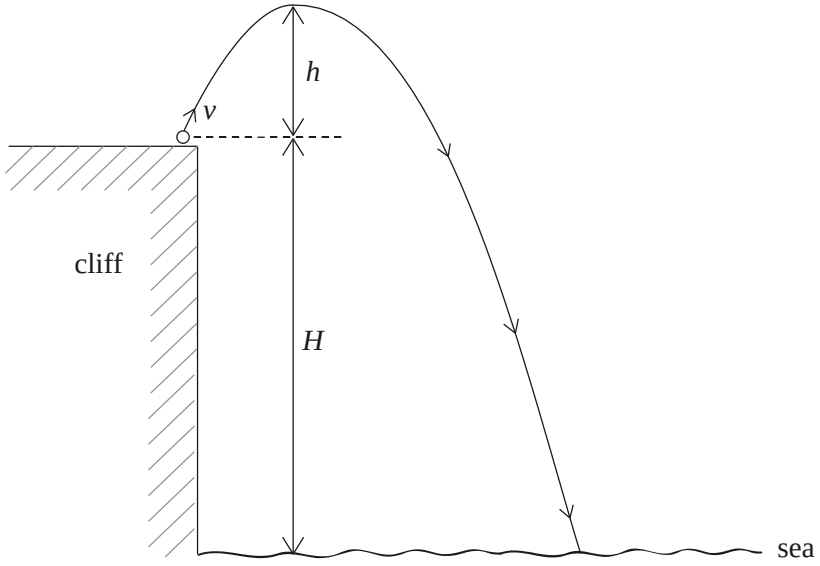
PART A /16	
PART B /59	
Total Mark /75	
KU /53	
WS /22	

This paper MUST NOT be removed from the examination room

Part A – 16 marks

Choose the most correct answer. Use the multiple-choice answer sheet for Questions 1–16

1. A stone is thrown with speed v from the top of a cliff of height H, as shown below.



The stone is thrown at an angle to the horizontal so that it rises to a height h above the top of the cliff before falling into the sea. The acceleration of free fall is g. Air resistance is negligible.

Which **one** of the following expressions correctly gives the speed of the stone as it hits the sea?

A. $v+\sqrt{(2gh)}$

B. $v+\sqrt{(2gH)}$

C. $\sqrt{(2g\{h+H\})}$

D. $\sqrt{(v^2+2gH)}$

2. A transformer has a primary coil with N_p turns and a secondary coil with N_s turns. An alternating voltage supply of frequency f and voltage V_p is connected to the primary coil.

Which of the following correctly gives the frequency and voltage in the secondary coil?

	Frequency	**Voltage**
A.	$\frac{N_s}{N_p}f$	$\frac{N_p}{N_s}V_p$
B.	f	$\frac{N_p}{N_s}V_p$
C.	$\frac{N_p}{N_s}f$	$\frac{N_s}{N_p}V_p$
D.	f	$\frac{N_s}{N_p}V_p$

3. The rings of Saturn are made of rocky particles that orbit the planet. The period T of each particle depends on its distance r from the centre of Saturn. The period T is proportional to r^n. Which **one** of the following is n equal to?

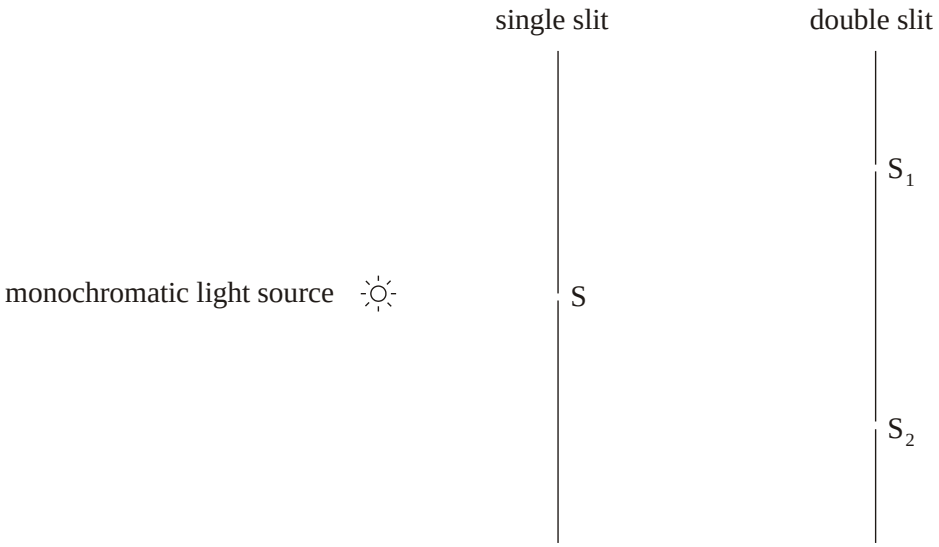
A. 1.0

B. 1.5

C. 2.0

D. 3.0

4. The diagram below shows the arrangement for a Young's double slit experiment.



The function of the single slit is

A. to direct the light towards S_1 and S_2.

B. to ensure equal intensities of light at S_1 and S_2.

C. to produce coherent light at S_1 and S_2.

D. to reduce the intensity of light at S_1 and S_2.

5. A proton of mass m and charge e is accelerated from rest through a potential difference V. The final speed of the proton is

A. $\sqrt{\frac{2Ve}{m}}$.

B. $\frac{2Ve}{m}$.

C. $\sqrt{\frac{Ve}{m}}$.

D. $\frac{Ve}{m}$.

6. Newton's law of gravitation for the force F between two point objects of masses M and m, separated by a distance d may be written as

$$Fd^2 \propto Mm.$$

The expression may also be used for the force of attraction between the Sun and the Earth, although they are not point masses. This is because

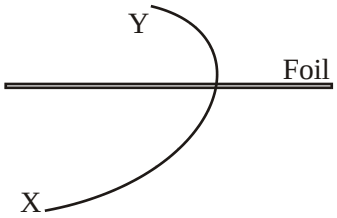
A. the gravitational constant G is not involved in the expression.

B. the force between the Sun and the Earth is very large.

C. the separation of the Sun and the Earth is much greater than their radii.

D. the mass of the Earth is much less than the mass of the Sun.

7. The diagram below shows the path XY of an electron that passes through a thin foil placed in a vacuum.



There is a uniform magnetic field acting perpendicularly to the plane of the page. Which **one** of the following statements best explains the path followed by the electron?

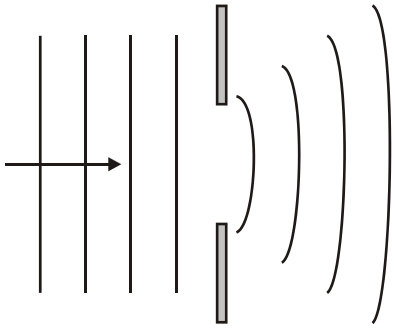
	Direction of motion of the electron	**Direction of the magnetic field**
A.	Y to X	into the plane of the page
B.	Y to X	out of the plane of the page
C.	X to Y	into the plane of the page
D.	X to Y	out of the plane of the page

8. A satellite is in orbit about Earth. The satellite moves to an orbit closer to Earth. Which of the following correctly gives the change in the potential energy and the kinetic energy of the satellite?

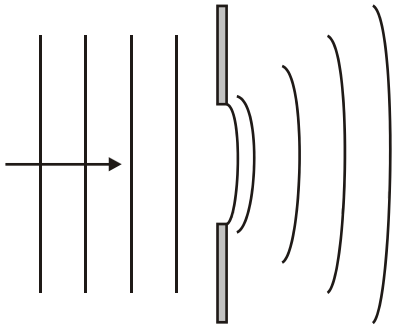
	change in potential energy	**change in kinetic energy**
A.	Decreases	Increases
B.	Decreases	Decreases
C.	Increases	Increases
D.	Increases	Decreases

9. Which diagram best shows diffraction of plane wavefronts at a single slit?

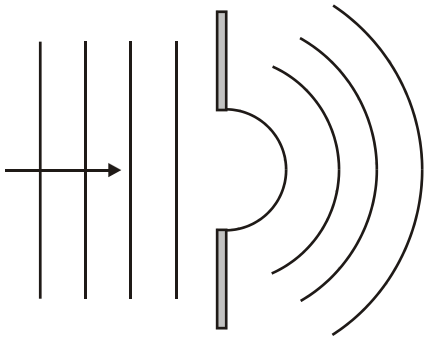
A.



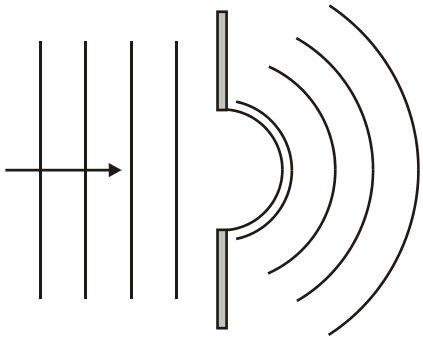
B.



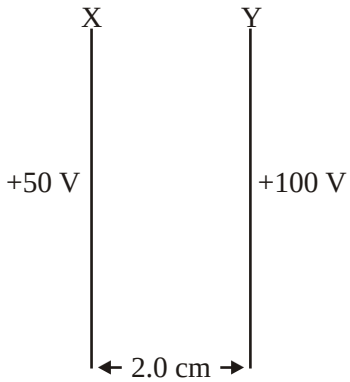
C.



D.



10. The diagram below shows two lines of equipotential in a region of a uniform electric field. Line X has a potential of +50 V and line Y has a potential of +100V. The distance between X and Y is 2.0 cm.



Which **one** of the following correctly gives the direction of the electric field and its strength?

	Direction	**Strength / V cm^{-1}**
A.	X → Y	25
B.	X → Y	100
C.	Y → X	25
D.	Y → X	100

11. Two satellites of equal mass, S_1 and S_2, orbit the Earth. S_1 is orbiting at a distance r from the Earth's centre at speed v. S_2 orbits at a distance $2r$ from the Earth's centre at speed $\frac{v}{\sqrt{2}}$. The ratio of the centripetal force on S_1 to the centripetal force on S_2 is

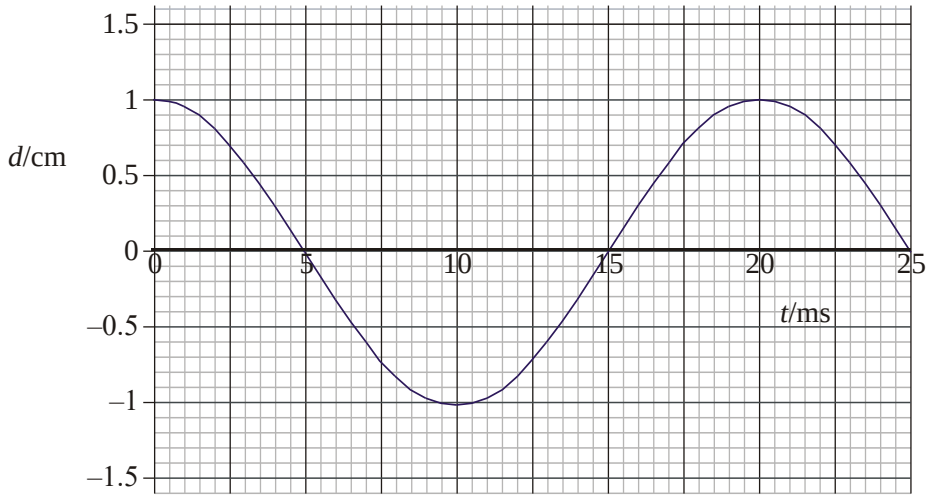
A. $\frac{1}{8}$.

B. $\frac{1}{4}$.

C. 4.

D. 8.

12. A wave is travelling through a medium. The diagram shows the variation with time t of the displacement d of a particle of the medium from $t = 0$ to $t = 25$ ms.



Which of the following correctly gives the frequency and the amplitude of the wave?

	frequency / Hz	amplitude / cm
A.	2.0×10^{-2}	2.0
B.	2.0×10^{-2}	1.0
C.	50	2.0
D.	50	1.0

13. Which **one** of the following is a correct definition of electric potential difference between two points?

A. The power to move a small positive charge between the two points.

B. The work done to move a small positive charge between the two points.

C. The power per unit charge to move a small positive charge between the two points.

D. The work done per unit charge to move a small positive charge between the two points.

14. The acceleration of free fall of a small sphere of mass 5.0×10^{-3} kg when close to the surface of Jupiter is 25 ms^{-2}. The gravitational field strength at the surface of Jupiter is

A. 2.0×10^{-4} N kg^{-1}.

B. 1.3×10^{-1} N kg^{-1}.

C. 25 N kg^{-1}.

D. 5.0×10^{3} N kg^{-1}.

15. The waves from two light sources meet at a point. Which condition is essential for interference to be observed?

A. Constant phase difference between the waves

B. Equal amplitude of the waves

C. Equal frequency of the waves

D. Equal intensities of the waves

16. The escape speed of an object of mass *m* from a planet of mass *M* and radius *r* depends on the gravitational constant and

A. *M* and *r*.

B. *m* and *r*.

C. *M* only.

D. *M*, *m*, and *r*.

Part B – 59 marks

Write your answers in the spaces provided

17. (a) Explain the term *black-body radiation*.

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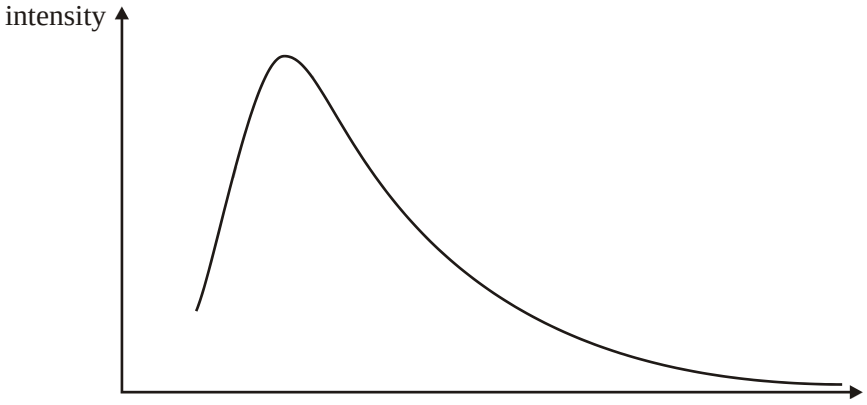
(1)

The diagram below is a sketch graph of the black-body radiation spectrum of a certain star.



(b) Label the *x*-axis of the graph.

(1)

(c) On the graph, sketch the black-body radiation spectrum of a star that has a lower surface temperature and lower apparent brightness than this star.

(1)

The star Betelgeuse in the Orion constellation emits black-body radiation that has a maximum intensity at a wavelength of 0.97 μm.

(d) Deduce that the surface temperature of Betelgeuse is about 3000 K.

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(1)

(Total 4 marks)

18. (a) State what is meant by polarised light.

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(1)

(b) Polarised light of intensity I_0 is incident on an analyser. The transmission axis of the analyser makes an angle θ with the direction of the electric field of the light.

(i) Calculate, in terms of I_0, the intensity of light transmitted through the analyser when $\theta = 60°$.

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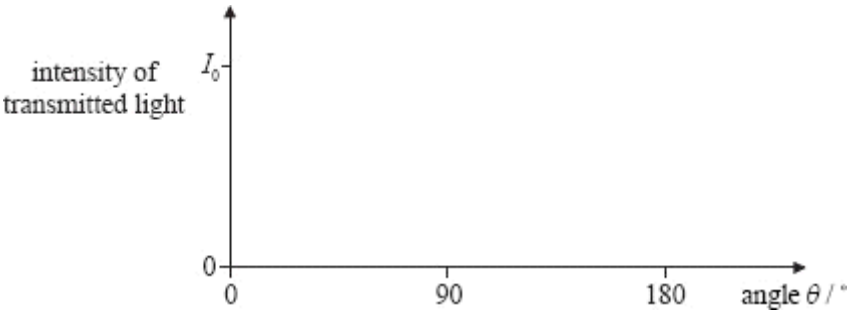
(1)

(ii) On the axes below, sketch a graph to show the variation with angle θ of the intensity of the transmitted light.



(2)

(c) Outline how polarising sunglasses reduce glare from a reflecting surface.

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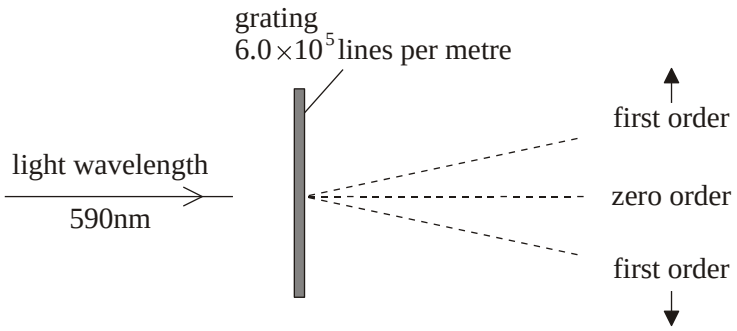
(2)

(Total 6 marks)

19. Light of wavelength 590 nm is incident normally on a diffraction grating, as shown below.



The grating has 6.0×10^5 lines per metre.

(a) Determine the **total** number of orders (both sides) of diffracted light, including the zero order, that can be observed.

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(4)

(b) The incident light is replaced by a beam of light consisting of two wavelengths, 590 nm and 589 nm.

State **two** observable differences between a first order spectrum and a second order spectrum of the diffracted light.

1. .....

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2. .....

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(2)

(Total 6 marks)

20. (a) A satellite goes round a planet at constant speed. Explain why, although its speed is constant, it is accelerating.

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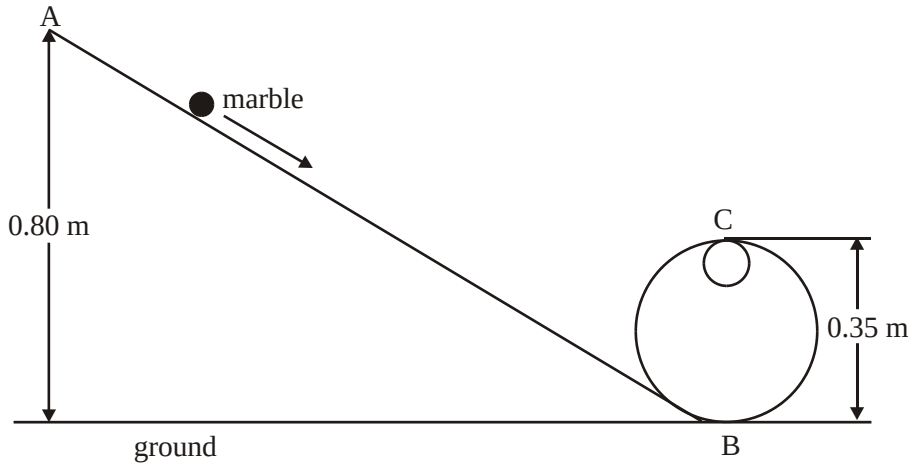
(1)

In the diagram below, a marble (small glass sphere) rolls down a track, the bottom part of which has been bent into a loop. The end A of the track, from which the marble is released, is at a height of 0.80 m above the ground. Point B is the lowest point and point C the highest point of the loop. The diameter of the loop is 0.35 m.



The mass of the marble is 0.050 kg. Friction forces and any gain in kinetic energy due to the rotating of the marble can be ignored.

Consider the marble when it is at point C.

(b) (i) On the diagram above, draw an arrow to show the direction of the resultant force acting on the marble.

(1)

(ii) State the names of the **two** forces acting on the marble.

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(2)

(iii) Deduce that the speed of the marble is approximately 3.0 ms^{-1}.

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(2)

(iv) Determine the resultant force acting on the marble and hence determine the reaction force of the track on the marble.

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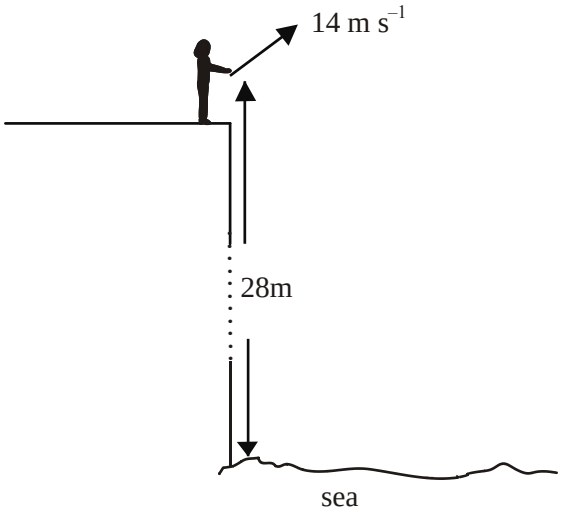
(3)
(Total 9 marks)

21. A stone is thrown from the top of a cliff of height 28 m above the sea. The stone is thrown at a speed of 14 m s^{-1} at an angle above the horizontal. Air resistance is negligible.



The maximum height reached by the stone measured from the point from which it is thrown is 8.0 m.

(a) By considering the energy of the stone, determine the speed with which the stone hits the sea.

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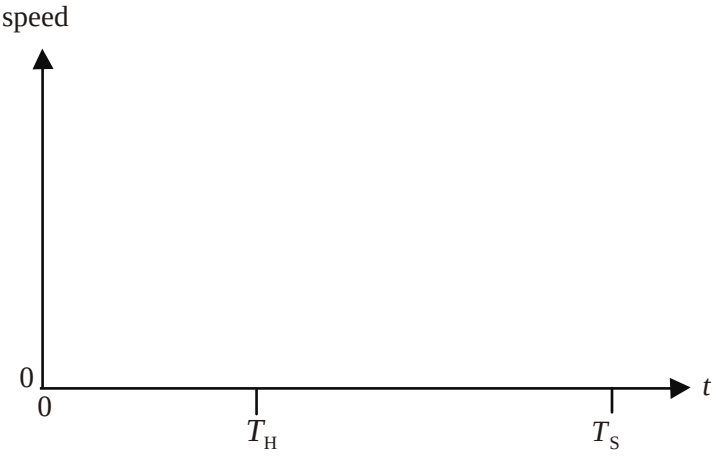
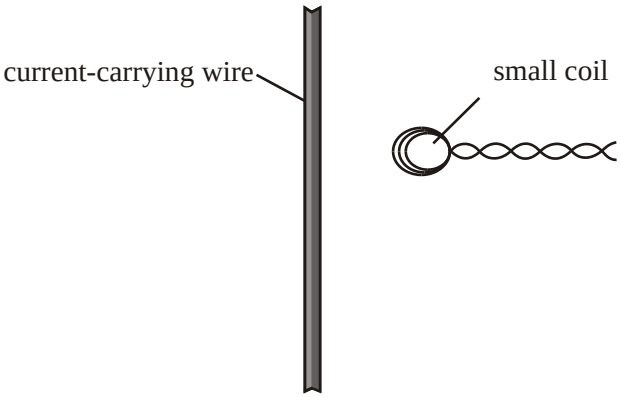
(2)

(b) The stone leaves the cliff at time $t = 0$. It reaches its maximum height at $t = T_H$. On the axis below, draw a sketch-graph to show the variation with time t of the magnitude of the **vertical** component of speed of the stone from $t = 0$ to $t = T_S$, the time just before the stone strikes the sea.



(2)
(Total 4 marks)

22. A small coil is placed with its plane parallel to a long straight current-carrying wire, as shown below.



(a) (i) State Faraday's law of electromagnetic induction.

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(2)

(ii) Use the law to explain why, when the current in the wire changes, an emf is induced in the coil.

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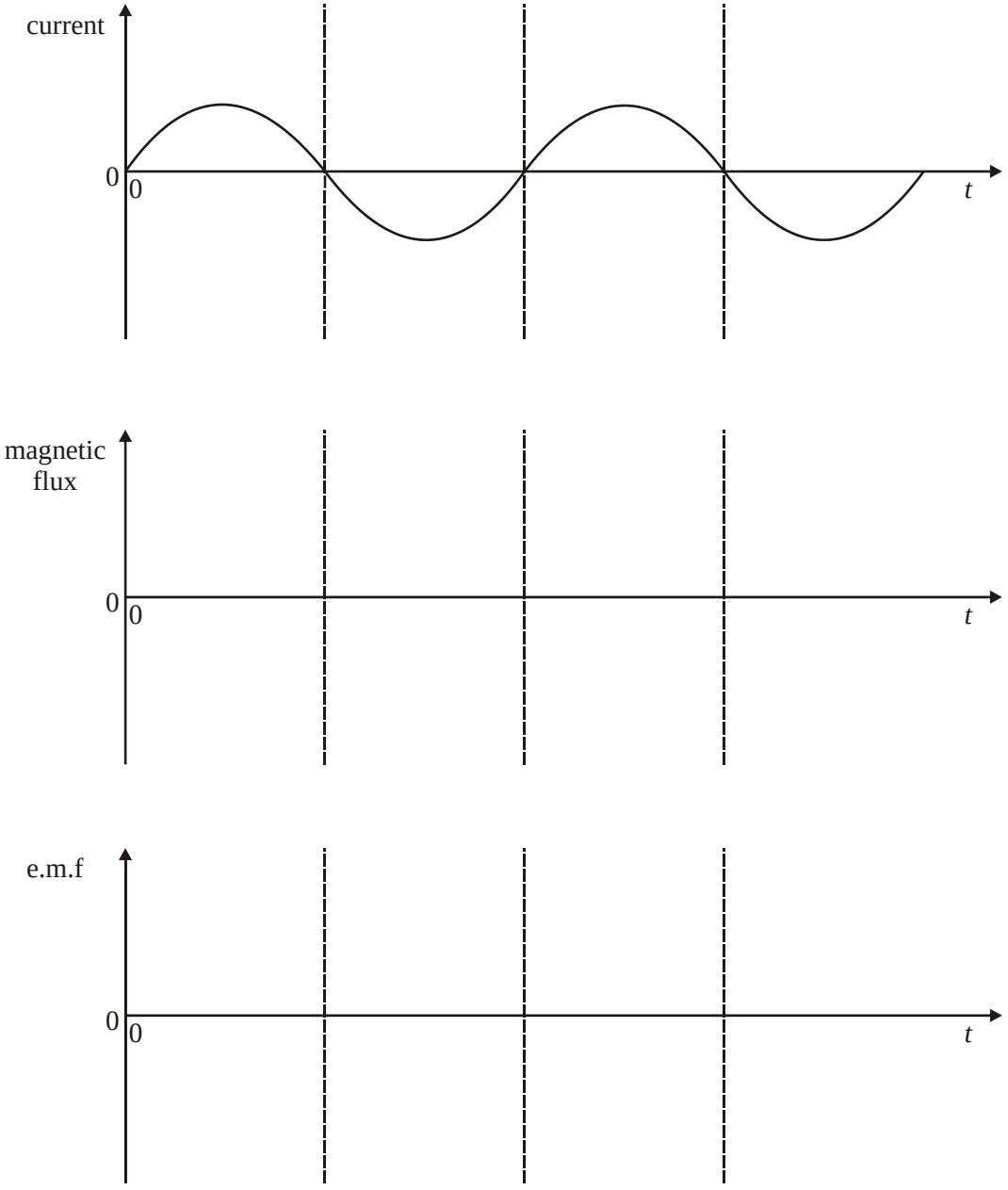
(1)

The diagram below shows the variation with time *t* of the current in the wire.



(b) (i) Draw, on the axes provided, a sketch-graph to show the variation with time *t* of the magnetic flux in the coil.

(1)

(ii) Construct, on the axes provided, a sketch-graph to show the variation with time *t* of the emf induced in the coil.

(2)

(iii) State and explain the effect on the maximum emf induced in the coil when the coil is further away from the wire.

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(2)

(c) Such a coil may be used to measure large alternating currents in a high-voltage cable. Identify **one** advantage and **one** disadvantage of this method.

Advantage: …..…….....

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Disadvantage: …..…….....

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(2)
(Total 10 marks)

23. This question is about Kepler's third law.

(a) Kepler's third law states that the period T of the orbit of a planet about the Sun is related to the average orbital radius R of the planet by the relationship

$$T^2 = KR^3$$

where K is a constant.

(i) Suggest why the law specifies the average orbital radius.

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(1)

(ii) State the name of the force that causes the acceleration of the planets orbiting the Sun.

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(1)

(iii) State an expression for the magnitude F of the force in (ii) in terms of the mass M_S, of the Sun, the mass m of the planet, the radius R of the orbit and the universal gravitational constant G.

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(1)

(iv) Hence deduce, explaining your working, that the constant K is given by the expression

$$K = \frac{4\pi^2}{GM_S}.$$

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(4)

(b) Ganymede is one of the moons of Jupiter and the following data are available.

Average orbital radius of Ganymede = 1.1×10^9 m

Orbital period of Ganymede = 6.2×10^5 s

Universal gravitational constant G = 6.67×10^{-11} N m^2 kg^{-2}

(i) Deduce that the gravitational field strength of Jupiter at the surface of Ganymede is approximately 0.1 N kg^{-1}.

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(2)

(ii) Estimate the mass of Jupiter.

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(3)

(Total 12 marks)

24. (a) Describe one historical method used to determine the speed of light experimentally including its limitations.

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(6)

continued on next page

(b) In 1983, the speed of light was declared to be exactly 299 792 458 ms^{-1}. Explain the currently accepted relationship of the speed of light to the measurement of distance and time.

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(2)
(Total 8 marks)

End of paper

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 m s^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Speed of light, c	3.00×10^8 m s^{-1}
Electric permittivity constant, ε_0	8.854×10^{-12} A^2 s^4 kg^{-1} m^{-3}
Magnetic permeability constant, μ_0	$4\pi \times 10^{-7}$ N A^{-2}
Universal gravitational constant, G	6.67×10^{-11} N m^2 kg^{-2}
Mass of Earth, M_E	6.0×10^{24} kg
Radius of Earth, r_E	6.371×10^6 m
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}
Wien's displacement constant, b	2.898×10^{-3} m K

FORMULAE SHEET

Motion, forces and gravity

$$s = ut + \frac{1}{2}at^2$$

$$v = u + at$$

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

$$\vec{F}_{net} = m\vec{a}$$

$$\Delta U = mg\Delta h$$

$$W = F_{||}s = Fs\cos\theta$$

$$P = \frac{\Delta E}{\Delta t}$$

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

$$P = F_{||}v = Fv\cos\theta$$

$$\sum \frac{1}{2}mv^2_{before} = \sum \frac{1}{2}mv^2_{after}$$

$$\sum m\vec{v}_{before} = \sum m\vec{v}_{after}$$

$$\Delta\vec{p} = \vec{F}_{net}\Delta t$$

$$a_c = \frac{v^2}{r}$$

$$\omega = \frac{\Delta\theta}{t}$$

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

$$\tau = r_\perp F = rF\sin\theta$$

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

$$v = \frac{2\pi r}{T}$$

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

$$U = -\frac{GMm}{r}$$

Waves and thermodynamics

$$v = f\lambda$$

$$f_{beat} = \left| f_2 - f_1 \right|$$

$$f = \frac{1}{T}$$

$$f' = f\frac{\left(v_{wave} + v_{observer}\right)}{\left(v_{wave} - v_{source}\right)}$$

$$d\sin\theta = m\lambda$$

$$n_1\sin\theta_1 = n_2\sin\theta_2$$

$$n_x = \frac{c}{v_x}$$

$$\sin\theta_c = \frac{n_2}{n_1}$$

$$I = I_{max}\cos^2\theta$$

$$I_1 r_1^2 = I_2 r_2^2$$

$$Q = mc\Delta T$$

$$\frac{Q}{t} = \frac{kA\Delta T}{d}$$

FORMULAE SHEET (continued)

Electricity and magnetism

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

$$V = \frac{\Delta U}{q}$$

$$W = qV$$

$$W = qEd$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B = \frac{\mu_0 NI}{L}$$

$$\Phi = B_{\parallel} A = BA\cos\theta$$

$$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$$

$$\frac{V_\mathrm{p}}{V_\mathrm{s}} = \frac{N_\mathrm{p}}{N_\mathrm{s}}$$

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

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

$$I = \frac{q}{t}$$

$$V = IR$$

$$P = VI$$

$$F = qv_{\perp}B = qvB\sin\theta$$

$$F = lI_{\perp}B = lIB\sin\theta$$

$$\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$$

$$\tau = nIA_{\perp}B = nIAB\sin\theta$$

$$V_\mathrm{p} I_\mathrm{p} = V_\mathrm{s} I_\mathrm{s}$$

Quantum, special relativity and nuclear

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

$$K_{\max} = hf - \phi$$

$$\lambda_{\max} = \frac{b}{T}$$

$$E = mc^2$$

$$E = hf$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_\mathrm{f}^2} - \frac{1}{n_\mathrm{i}^2}\right)$$

$$t = \frac{t_0}{\sqrt{\left(1 - \dfrac{v^2}{c^2}\right)}}$$

$$l = l_0\sqrt{\left(1 - \frac{v^2}{c^2}\right)}$$

$$p_\mathrm{v} = \frac{m_0 v}{\sqrt{\left(1 - \dfrac{v^2}{c^2}\right)}}$$

$$N_\mathrm{t} = N_0 e^{-\lambda t}$$

$$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$$

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number
Symbol
Standard Atomic Weight
Name

Example: 79 Au 197.0 Gold

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	57–71 Lanthanoids	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	89–103 Actinoids	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	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson

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

STUDENT NUMBER: _____

North Sydney Boys High School
Science Faculty
HSC Physics 2022
Assessment 3

MULTIPLE CHOICE ANSWER SHEET

1.	**A** ◯	**B** ◯	**C** ◯	**D** ◯
2.	**A** ◯	**B** ◯	**C** ◯	**D** ◯
3.	**A** ◯	**B** ◯	**C** ◯	**D** ◯
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** ◯

Marking Guideline Year 12 Physics Trial Exam 2022

Note: Working Scientifically marks have (WS)

1. D 1

2. D

3. B

4. C

5. A

6. C

7. D

8. A

9. A

10. C

11. C

12. D

13. D

14. C

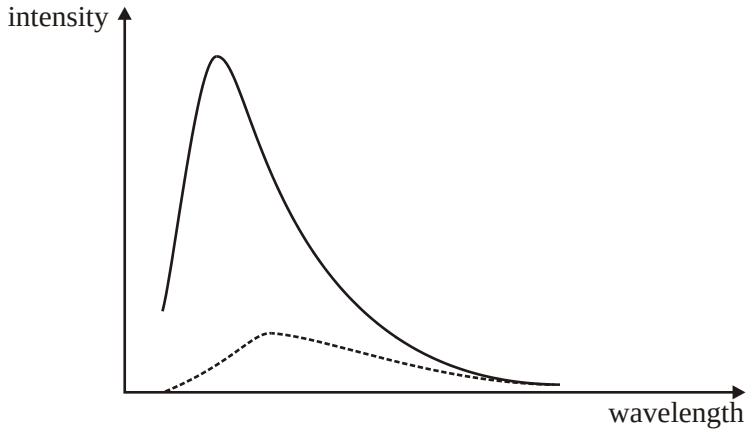
15. A

16. A

17. (a) the radiation emitted by a perfect emitter or a perfect absorber 1

(b) wavelength / λ; 1

(c)



lower intensities with peak shifted to the longer wavelength; 1

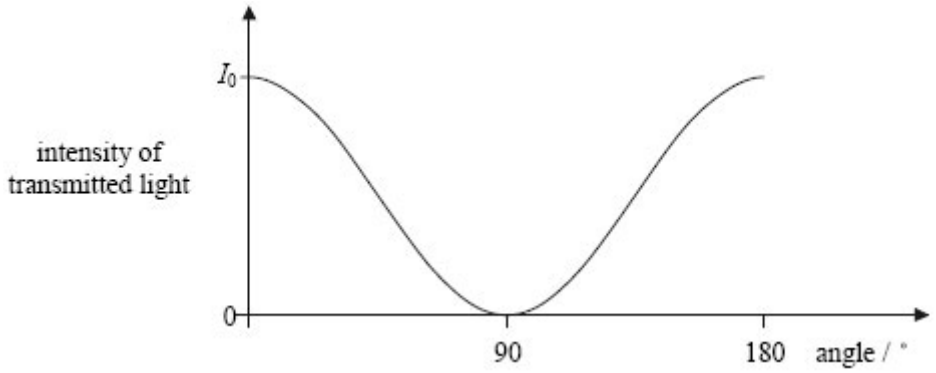
(d) $T = \dfrac{2.90\times10^{-3}}{\lambda} = \dfrac{2.90\times10^{-3}}{9.70\times10^{-7}}$ = 3000 *K*; 1

[4]

18. (a) light where the direction of the (electric) field is always (or predominantly) in the same plane; 1

(b) (i) $I = \left(I_0 \cos^2 60°\right) = \dfrac{I_0}{4}$; 1

(ii)



general $\cos^2$ shape; 1 (WS)
max at $\theta = 0$ and curve touches horizontal axis at $\theta = 90°$; 1 (WS)

(c) light is (partially) horizontally polarised by reflection; 1
sunglasses have a transmission axis at 90° to the plane of reflected light causing the intensity of reflected light to be reduced; 1

[6]

19. (a) using $d\sin\theta = m\lambda$ and the idea that max m is achieved when $\sin\theta = 1$; 1

making use of $d = \frac{1}{6.0\times10^5}$; 1

to give m = 2.8; 1

hence there are five complete orders; (2 orders on each side including zeroth) 1

(b) Spectrum/lines are brighter in the first order; 1
Lines more likely to be seen separately in second order; 1

[6]

20. (a) the direction of the planet's trajectory is changing hence the velocity of the planet is changing; 1

(b) (i) arrow pointing vertically downwards; 1

(ii) weight (or gravity); 1
normal force/reaction force; 1

(iii) loss in PE = 0.05 × 9.8 × (0.8 – 0.35);
= gain in KE = $\frac{1}{2}mv^2$; 1

to give v = 2.97 m s^{-1} (3.0 m s^{-1}); 1

or

use of $v = \sqrt{2gh}$ to give v = 4.0 m s^{-1} at point B;

and then use of $v^2 - u^2 = 2gh$ with u = 4.0 m s^{-1} and h = 0.35 m;
g = - 9.8 m s^{-2} to get v = 3.0 m s^{-1};

(iv) recognise that resultant force = $\frac{mv^2}{r} = \frac{(0.05\times9.0)}{0.175}$ = 2.6 N; 1

N = $\frac{mv^2}{r} - mg$; (must be stated) 1

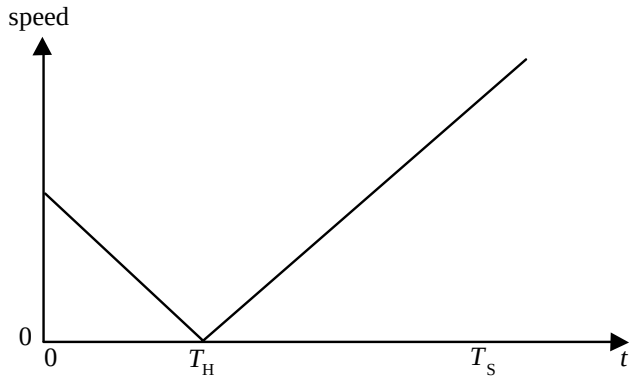
= 2.6 – 0.5 = 2.1 N; 1

[9]

21. (a) initial KE of stone + loss in PE = gain in KE (must indicate this relationship); 1

$\frac{14^2}{2} + 9.8 \times 28 = \frac{v^2}{2}$ to give v = 27 m s^{-1} (mass cancels out); 1

(b)



two lines going in the correct direction as shown; 1 (WS)
speed greater at T_S than initial speed and zero at T_H (slope magnitudes equal); 1 (WS)

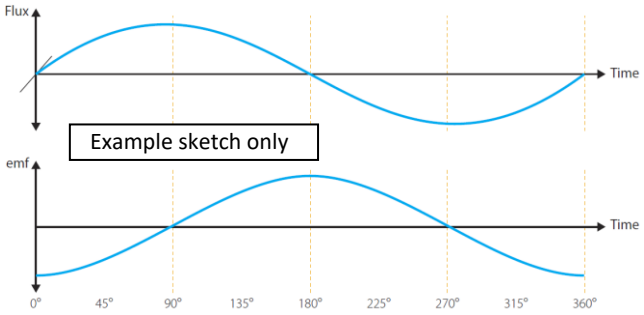
[4]

22. (a) (i) <u>emf</u> (induced) is proportional to; 1 (WS)
rate of change / cutting of (magnetic) flux; 1 (WS)

(ii) magnetic field / flux <u>through coil</u> will change as the current changes; 1 (WS)

(b) (i) sinusoidal and in phase with current; 1 (WS)

(ii) sinusoidal and same frequency; 1 (WS)
with 90° phase difference to graph for φ and Lenz's law implemented; 1 (WS)



(iii) emf is reduced; 1 (WS)
because B is smaller; 1 (WS)

(c) advantage: no direct contact with cable required; 1 (WS)
disadvantage: distance to wire must be fixed; 1 (WS)

[10]

23. Kepler's third law

(a) (i) the orbits are elliptical / not circular; 1
Do not accept "because R changes".

(ii) gravity / gravitational; 1

(iii) $F = G\dfrac{M_s m}{R^2}$; 1

Same symbols as in question must be used to receive the mark.

(iv) let v = the speed of planet, the acceleration is then = $\dfrac{v^2}{R}$ 1

from Newton 2, $F = G\frac{M_s m}{R^2} = \frac{mv^2}{R}$; { *Some reference to Newton 2 is required to receive this mark.* } 1

$v = \frac{2\pi R}{T}$; therefore, = $G\frac{M_s m}{R^2} = \frac{4\pi^2 m R^2}{T^2}$; 1

therefore, $T^2 = \frac{4\pi^2}{GM_s}R^3$; so $K = \frac{4\pi^2}{GM_s}$ 1

(b) (i) recognise that gravitational field strength = $\frac{v^2}{R} = \frac{4\pi^2 R}{T^2}$; 1

$= \frac{40 \times 1.1 \times 10^9}{\left(6.2 \times 10^5\right)^2}$; $= 0.1 \text{Nkg}^{-1}$ 1

(ii) $T^2 = \frac{4\pi^2}{GM_s}R^3$ therefore, $M_{jup} = \frac{4\pi^2 R^3}{GT^2}$; 2

$M_{jup} = \frac{4\pi^2 \times (1.1)^3 \times 10^{27}}{6.7 \times 10^{-11} \times \left(6.2 \times 10^5\right)^2}$; $\approx 2.0 \times 10^{27}$ kg; 1

Or

$0.1 = \frac{GM}{R^2}$; $M = \frac{0.1R^2}{G}$; = $\frac{0.1 \times \left(1.1 \times 10^9\right)^2}{6.7 \times 10^{-11}}$ $\approx 2.0 \times 10^{27}$ kg;

[12]

24.

Historical method to measure speed of light experimentally	**Marks**
Provides a basic, labelled sketch of the procedure used	1(WS)
Describes the basic operation of the method. (Determination of speed purely from theory such as from Maxwell's laws is not accepted)	1(WS)
Explains the physics principles behind the method (example: reflection of light, law of reflection, finite speed of light, orbital motion of planets/moons, eclipses, light aberration, interference patterns, angular rotation/speed, etc.) Need to list two physics principles at least.	2(WS)
Describes two limitations of the technique/results obtained (example: slow human reaction time, short distances for light travel, limitation of timing devices, irregular orbits, etc)	2(WS)

Relationship of speed of light to time and distance	**Marks**
Explains that the metre is defined as the length of the path travelled by light in a vacuum in 1/c seconds	1(WS)
Explains that one second is defined as the time taken for a fixed number (9,192,631,770) of energy transitions in a Caesium 133 atom. (Note: exact number of transitions are not required but Caesium 133 atom must be stated)	1(WS)

[8]