SCIENCE TEACHERS ASSOCIATION VICTORIA 2024

TRIAL EXAMINATION

QUESTION AND ANSWER BOOK

Total writing time:
2 hours 30 minutes

PHYSICS
UNITS 3 & 4

Student name	

Student ID									**Letter**	

Structure of the trial examination

Section	Number of questions	Number of marks
A	20	20
B	19	100
	Total	**120**

- Students are permitted to bring into the trial examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, pre-written notes (one folded A3 sheet or two A4 sheets bound together by tape) and one scientific calculator.
- Students are NOT permitted to bring mobile phones and/or any other unauthorized electronic devices into the trial examination room.

Materials supplied

- Questions of 32 pages
- Separate multiple-choice answer sheet.
- Separate formula sheet

Instructions

- Write your name and student number in the space provided on this page and on the multiple-choice answer sheet.
- Unless otherwise indicated, the diagrams in this trial examination are **not** drawn to scale.
- All written responses must be in English.

At the end of the trial examination

- Hand in your trial examination answers and your multiple-choice answer sheet.

Published by STAV

STAV House, 5 Munro Street,
Coburg VIC 3058 Australia

PHONE: 61 + 3 9385 3999
EMAIL: admin@stav.vic.edu.au
ABN: 59 004 145 329

stav.org.au

Section A – Multiple-choice questions

Instructions

- Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
- Choose the response that is **correct** or that **best answers** the question.
- A correct answer scores 1; an incorrect answer scores 0.
- Marks will **not** be deducted for incorrect answers.
- No marks will be given if more than one answer is completed for any question.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1

The pressure gauge shown in the picture on the right measures gas pressure from −100 kPa to 500 kPa.

The reading on the gauge is best given as

A. 15 ± 10 kPa

B. 15 ± 5 kPa

C. −15 ± 10 kPa

D. −15 ± 5 kPa

Question 2

Which one of the following statements is incorrect?

A. Within an inertial frame of reference velocities can only be measured against that inertial frame of reference.

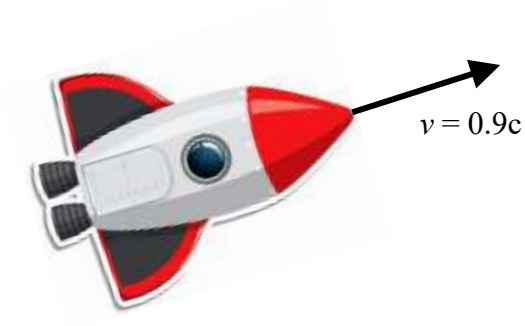
B. Within an inertial frame of reference Newton's 3 laws can only be used for objects that are travelling at close to the speed of light.

C. Within an inertial frame of reference, it is not possible to determine the absolute velocity of an object.

D. Within an inertial frame of reference time does not dilate for any object travelling at any speed.

Question 3

A spaceship is travelling at 0.9c on a trip to Alpha Centauri.



What is the Lorentz factor for the spaceship?

A. 2.29

B. 3.16

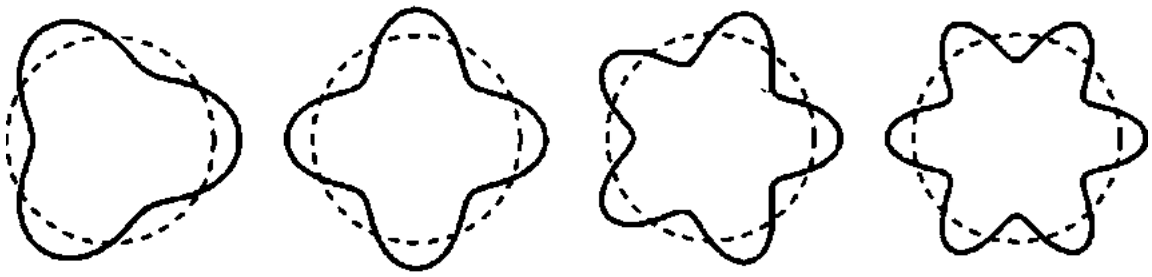
C. 5.26

D. 10

Question 4

Bohr's model of the atom used the idea of 'fitting' electrons into certain radius orbits around the nucleus according to their de Broglie wavelength. Which of the following diagrams could represent the n = 5 principal quantum number?

A. **B.** **C.** **D.**



Question 5

To halve the power being lost in electrical transmission lines the current in the transmission lines will need to

A. double

B. halve

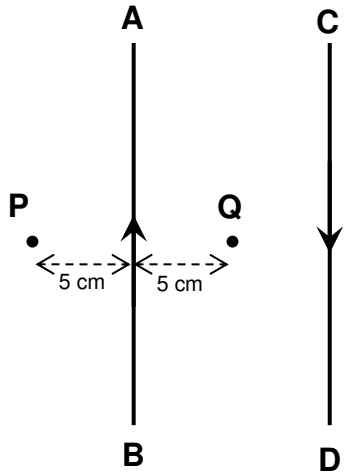
C. increase by a factor of 1.41

D. decrease by a factor of 1.41

Use the following information to answer Questions 6 and 7.

In the diagram below, **AB** and **CD** represent current carrying wires. The arrows indicate the direction of the current in each of the wires. The currents in each wire are equal in size but opposite in direction. The two wires are 10 cm apart.

The point **Q** is halfway between the wires and the point **P** is 5 cm to the left of wire **AB**.



Question 6

The net magnetic field at the point **P** associated with the currents in the wires **AB** and **CD** is in the direction

A. to the left

B. to the right

C. into the page

D. out of the page

Question 7

If the magnetic field strength at the point **P** due ***only*** to the current in wire **AB** is **X** units, then the magnetic field strength at point **Q,** due to the current in both wires, is

A. **2X**

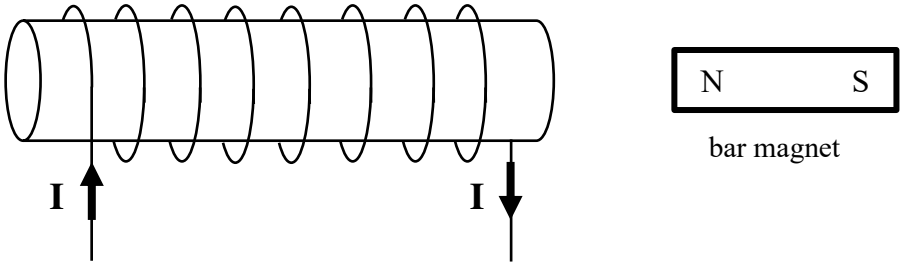
B. **3X**

C. **½ X**

D. **0**

Question 8

A small bar magnet is held close to the end of a stationary current carrying solenoid as shown below. The direction of the current in the solenoid is given by the arrows.



The direction of the magnetic force on the bar magnet is

A. to the left

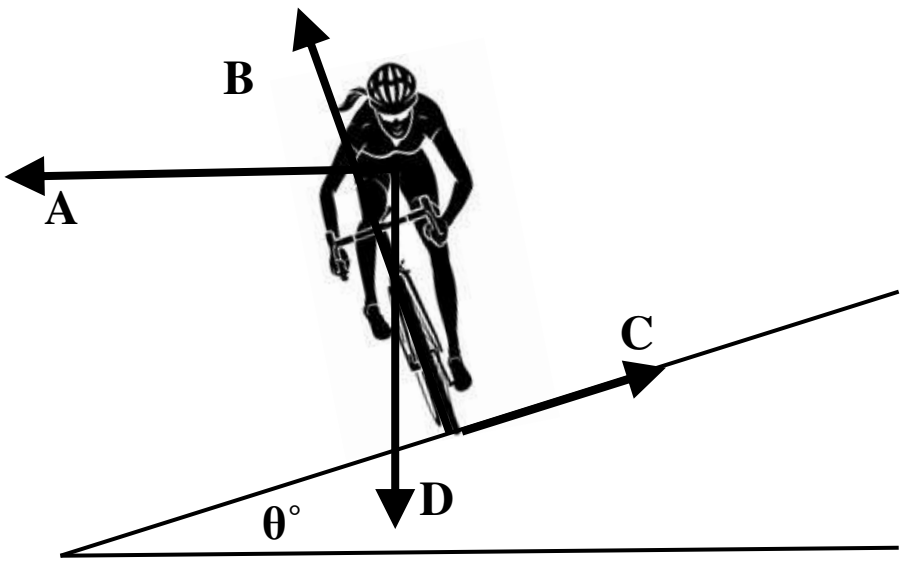
B. to the right

C. up the page

D. into the page

Question 9

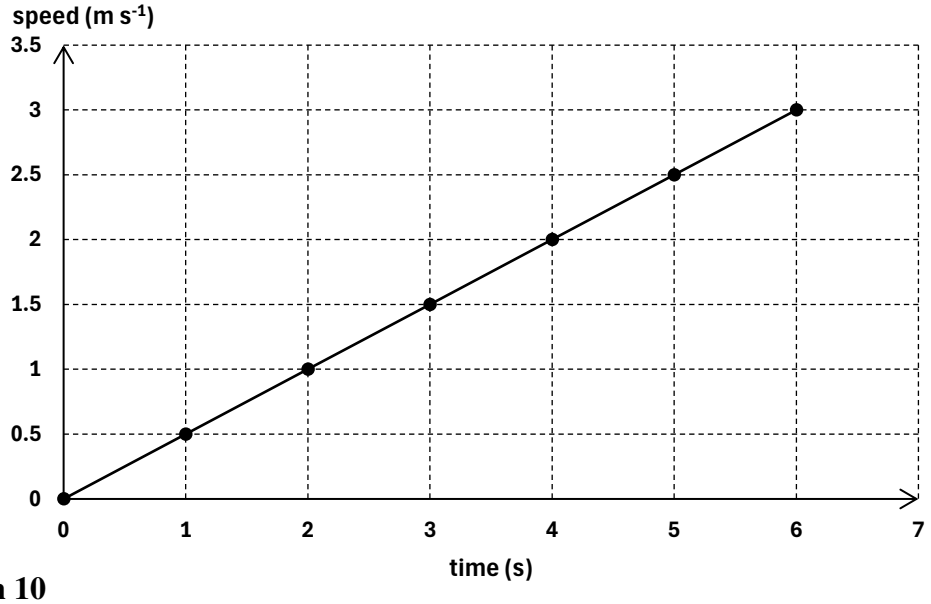
The diagram below shows the front view of a bicycle and rider moving out of the page as they travel around a circular track that is banked at an angle of θ˚.



Which of the arrows (**A** − **D**) on the diagram above shows the normal force acting on the cyclist by the road?

Use the following information to answer Questions 10 and 11.

The speed of a cyclist is plotted against time as shown in the graph below. The cyclist and their bicycle have a mass of 100 kg.



Question 10

How far did the object travel between t = 3 s and t = 4 s?

A. 1.75 m

B. 2.0 m

C. 4.0 m

D. 8.0 m

Question 11

What is the magnitude of the net force acting on the cyclist and his bicycle at t = 5 s?

A. 50 N

B. 125 N

C. 250 N

D. 500 N

Question 12

In a photoelectric effect experiment, the frequency of the incident radiation is greater than the threshold frequency. As the frequency of the incident radiation on the photosensitive surface decreases, the maximum kinetic energy of the emitted photoelectrons will

A. increase.

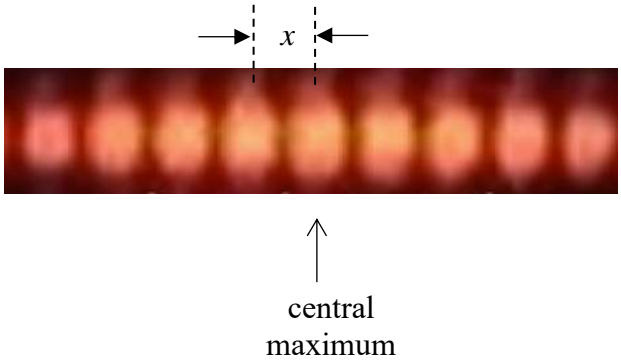
B. decrease.

C. remain the same.

D. vary depending on the incident radiation intensity.

Use the following information to answer Questions 13 and 14.

The diagram below represents the interference pattern produced by a source of monochromatic light of wavelength 6.0×10^{-7} m. The light is incident upon two slits that are 2.0×10^{-5} m apart and 1.5 m from the screen. The spacing between the centre of the bright bands is x cm.



Question 13

What is the value of the band spacing distance x in cm?

A. 8×10^{-10} cm

B. 3.0 cm

C. 4.5 cm

D. 2 200 cm

Question 14

If the light source is made brighter with no other changes, then the distance x will

A. decrease.

B. increase.

C. remain the same.

D. cannot be determined without further information.

Question 15

Standing waves can be produced in a string because of the phenomenon of

A. reflection

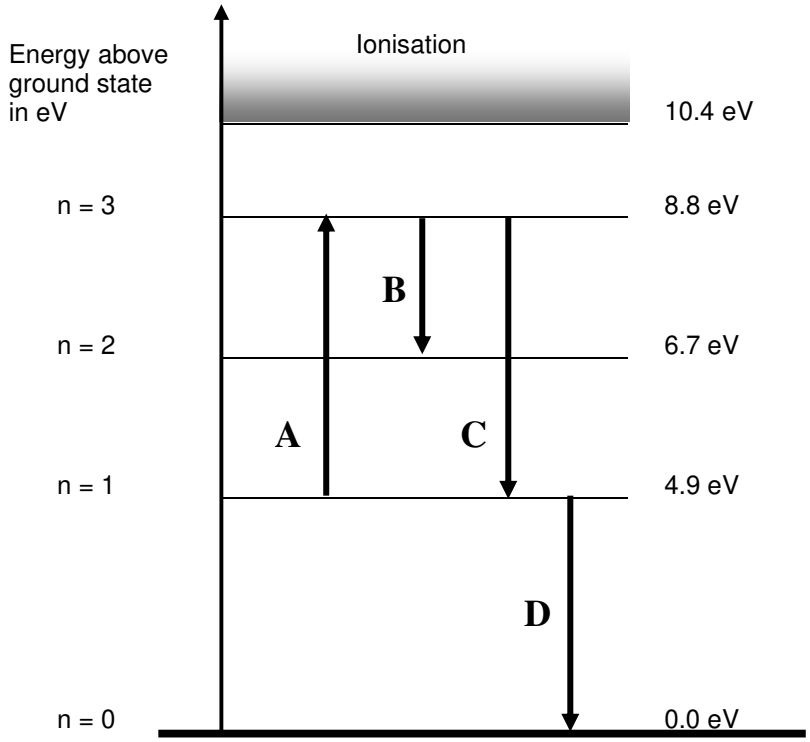
B. refraction

C. diffraction

D. dispersion

Question 16

The following diagram shows the quantised energy levels of a mercury atom, relative to the ground state. On the diagram which of the arrows (**A** − **D**) corresponds to the emission of a 3.9 eV photon?



Question 17

A wave travelling between fixed points A and B produces a standing wave on a rope, as represented in the diagram below.

The distance from point A to point B is 1.2 m. The wave is traveling at 4.0 m s^{-1} along the rope.

The wavelength of this wave is

A. 0.3 m

B. 0.4 m

C. 0.8 m

D. 1.2 m

Question 18

From the sun, the solar energy is radiated in the form of

A. infrared waves.

B. ultraviolet waves.

C. transverse waves.

D. electromagnetic waves.

Question 19

At Melbourne (37° South latitude) to gain maximum incident radiation from the sun, solar panels should face North and be elevated to

A. 37° to the vertical.

B. 37° to the horizontal.

C. 43° to the vertical.

D. 43° to the horizontal.

Question 20

The efficiency of photovoltaic cells in converting sunlight to electricity is of the order of

A. 5%

B. 20%

C. 75%

D. 98%

END OF SECTION A

Section B

Instructions

- Answer **all** questions in the spaces provided.
- Where an answer box is provided, write your final answer in the box.
- If the answer box has a unit printed in it, give your answer in that unit.
- In questions where more than one mark is available, appropriate working **must** be shown.
- Unless otherwise indicated diagrams are **not** drawn to scale.

Question 1 (11 marks)

Monica is riding her bicycle at a constant speed of 12 m s^{-1} when she applies the brakes and comes to rest. Monica and her bicycle have a combined mass of 75 kg.

a. What is Monica and her bicycle's kinetic energy prior to applying the brakes?

J

[2 marks]

b. What is the magnitude of Monica and her bicycle's momentum prior to applying the brakes?

kg m s^{-1}

[2 marks]

c. Monica came to rest in 15 m after applying the brakes. What was the magnitude of the average braking force exerted on Monica and her bike?

N

[3 marks]

d. When Monica comes to rest both her momentum and kinetic energy are zero. Explain what has happened to both these quantities.

_____

_____

_____

_____

[2 marks]

e. Determine if Monica braking and coming to rest is an elastic or inelastic interaction.

Circle your choice: **Elastic** **Inelastic**

Explain your choice.

_____

_____

_____

_____

_____

[2 marks]

Question 2 (7 marks)

A student is experimenting with circular motion by twirling a 50 g mass on the end of a piece of string 30 cm long in a vertical circle.

a. What is the tension in the string at the top of the vertical circle if the speed of the mass is 4.0 m s^{-1} at that point?

N

[3 marks]

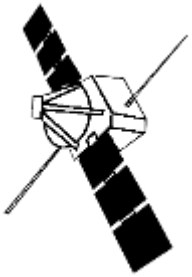
b. How fast is the mass travelling at the bottom of the circle assuming the student twirling the mass adds no further energy into the system as he twirls it?

m s^{-1}

[4 marks]

Question 3 (5 marks)

A geostationary satellite is orbiting the Earth.



a. Show by an appropriate calculation that the radius of a geostationary orbit is approximately 42 000 kilometres.

[3 marks]

b. What is the speed of a communications satellite of mass 120 kg, in geostationary orbit?

m s^{-1}

[2 marks]

Question 4 (9 marks)

At a local cricket match Glenn hits the ball from the middle of the ground, for a horizontal distance of 120 m, across the boundary on the full for a six. The ball rose to a maximum height of 24 m above ground level.

Assume the ball started its journey at ground level and that air resistance can be ignored.

a. How long was the ball in the air?

s

[2 marks]

b. At what speed did the ball leave Glenn's bat?

m s^{-1}

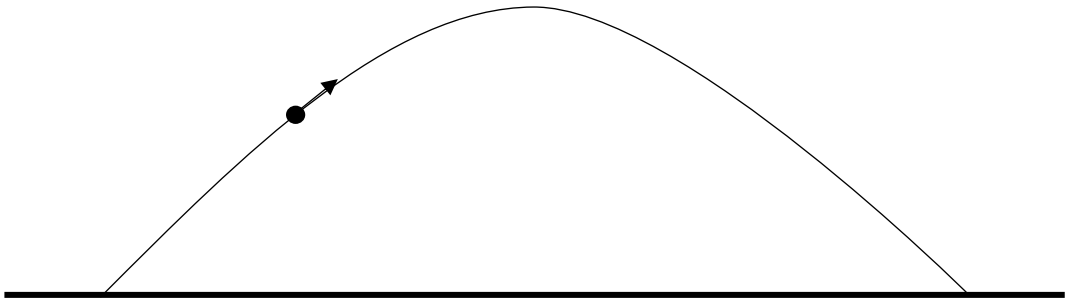
[3 marks]

c. At what angle to the horizontal did the ball leave Glenn's bat?

°

[2 marks]

d. Glenn plays another shot. Below is the path of the ball if air resistance is ignored.



If air resistance is considered, draw on the diagram above a possible path along which the ball might travel.

[2 marks]

Question 5 (3 marks)

Take the current mass of the International Space Station (ISS) to be 227 tonnes.

The ISS orbits the Earth at an average altitude of 354 kilometres.

What is the period of the ISS in seconds?

	s

[3 marks]

Question 6 (1 mark)

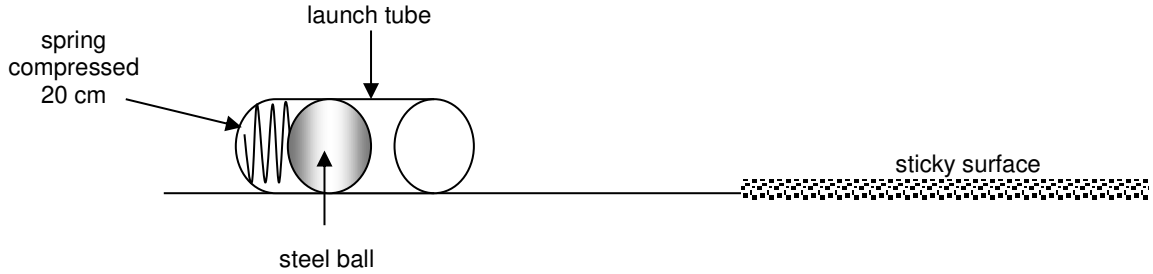
Connect each of the three following fields with an arrow to the correct descriptor for field type.
(A descriptor can be used for more than one field.)

Field	Descriptor
Gravitational	
	Monopole
Electric	
	Dipole
Magnetic	

[1 mark]

Question 7 (6 marks)

In a pinball game a steel ball of mass 0.15 kg is fired out of a launch tube by a compressed spring. The steel ball leaves the tube at 4.2 m s^{-1} when the spring has been compressed by 20 cm.



a. Assuming the spring is 'ideal', what is the value of the spring constant, k ?

N m^{-1}

[3 marks]

b. While travelling at 4.2 m s^{-1} the steel ball encounters a sticky surface and comes to rest due to the friction in 1.5 m. What is the magnitude of this friction force, assuming it is constant?

N

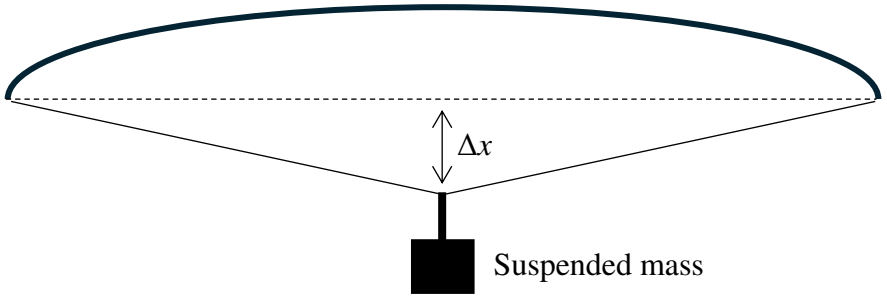
[3 marks]

Question 8 (11 marks)

As part of their practical investigation, some students investigate a simple long bow consisting of a wooden bow and string. The bow is fixed horizontally with the string to the bottom as shown below. The students hang various masses at the midpoint of the bowstring.

Unstretched bow

Stretched bow



Taking the string position with no masses suspended as the 'zero' of extension, the distance between this point and the point where the masses were suspended is the extension Δx.
The students suspended various masses from the middle point of the string and noted the vertical extension, Δx, of the bow and string system. They used a ruler with centimetre graduations to take readings of the extension of the string, Δx, with an uncertainty of ±0.5 cm.

The results of their investigation are shown in the table below.

Mass (kg)	Force (N)	Extension, Δx (cm)
0.00	0.0	0
0.30		2.1
0.60		4.0
0.90		6.0
1.30		6.8
1.70		7.5
1.90		8.0

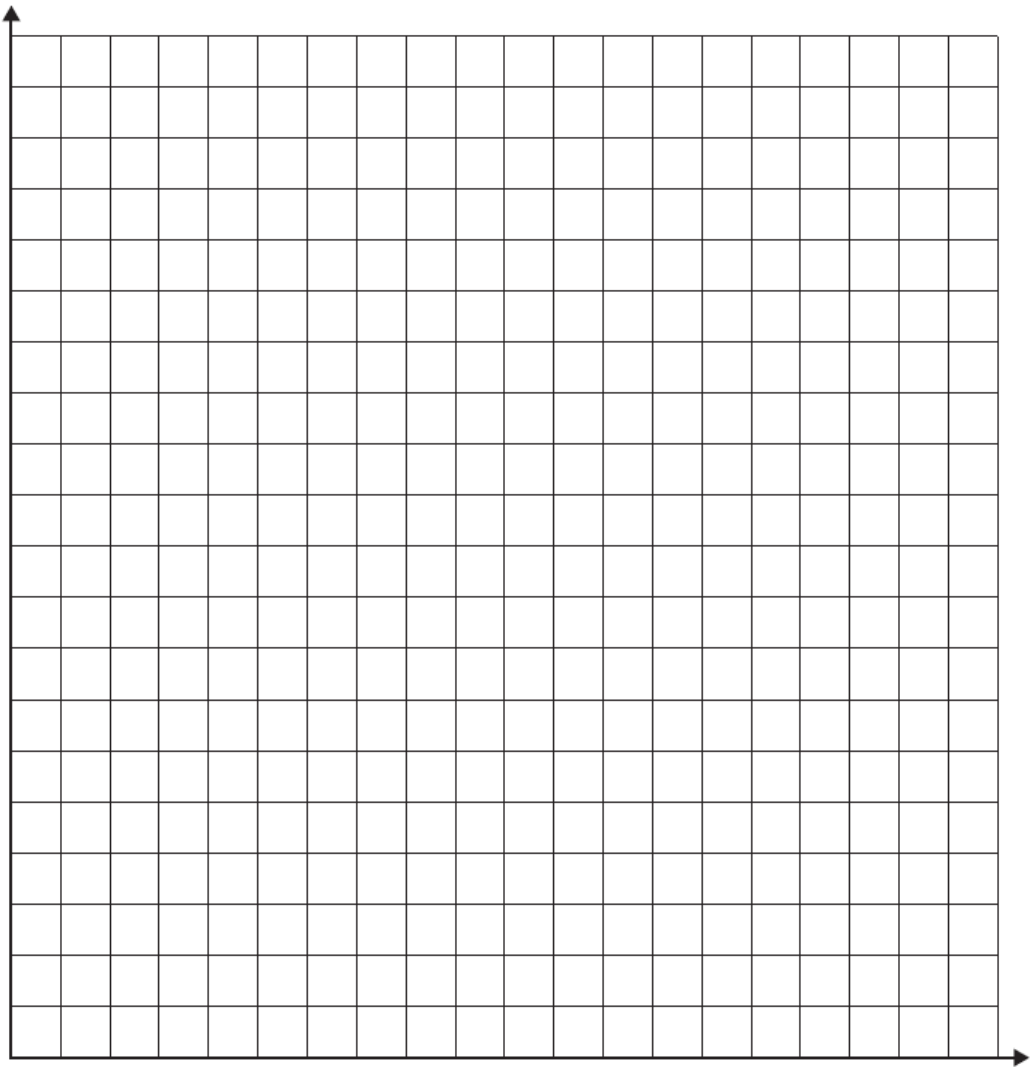
a. Fill in the correct values for the missing Force values to 1 decimal place in the table above.

[2 marks]

b. On the axes provided below:

- plot a graph of force (F) versus extension (Δx) for the bow and string system
- include scales and units on each axis
- insert appropriate uncertainty bars for the extension values on the graph
- draw a line that best fits the data up to an extension of 6.0 cm only

F ( )



Δx ( )

[5 marks]

c. Determine the value of the spring constant for the bow and string system, k, up to an extension of 6.0 cm. Show your working.

N m^{-1}

[2 marks]

d. Using the area under the force (F) versus extension (Δx) graph, or otherwise, determine the potential energy stored in the bow and string system when the system was extended by 5.0 cm. Show your working.

J

[2 marks]

Question 9 (5 marks)

Cross out the incorrect term in each bracket in the following statements.

Inverters take {*low voltage / high voltage*}and {*high current / low current*} signals from the PV panels and convert them into {*12 V_{DC} / 240 V_{AC}*}, which is directly compatible with grid power.

To increase output voltage solar cells are connected in {*series / parallel*}.

To increase output current solar cells are connected in {*series / parallel*}.

[5 marks]

Question 10 (2 marks)

A solar panel is rated at 200 W. If the panel is only 12% efficient how many joules of solar energy is incident on the surface of the solar panel every minute?

J

[2 marks]

Question 11 (4 marks)

The efficiency of solar panels is affected by several factors. Give two examples and discuss how they affect the efficiency of electricity production.

Example one

_____

_____

_____

_____

Example two

_____

_____

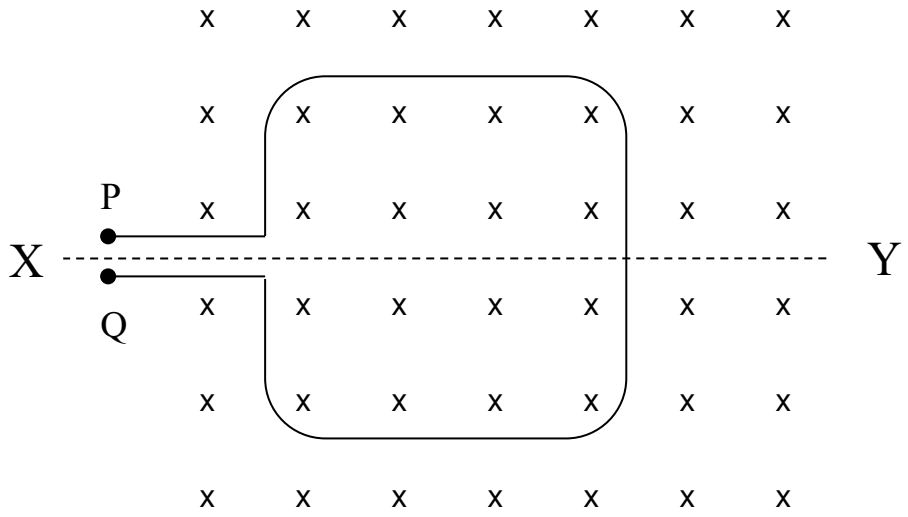
_____

_____

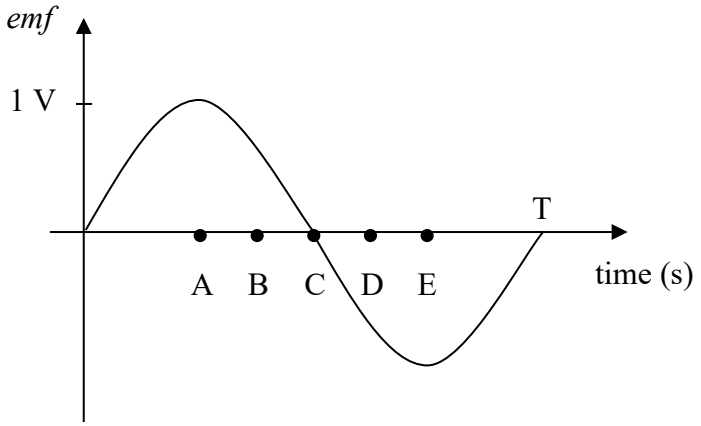
[2 + 2 = 4 marks]

Question 12 (3 marks)

A rectangular coil of wire is placed in a uniform magnetic field which is directed into the page, indicated by the crosses (x). The coil rotates about the axis XY at a uniform rate with period T seconds. At the instant depicted in the coil and field diagram below, the plane of the coil is perpendicular to the magnetic field.



The variation of the *emf* between P and Q with time due to the rotation of the coil in the magnetic field is shown in the graph below.



a. At which one of the instants A − E shown on the graph above, could the coil be in the position as shown in the top diagram of the coil in the field? (one or more answers)

Explain your choice.

_____

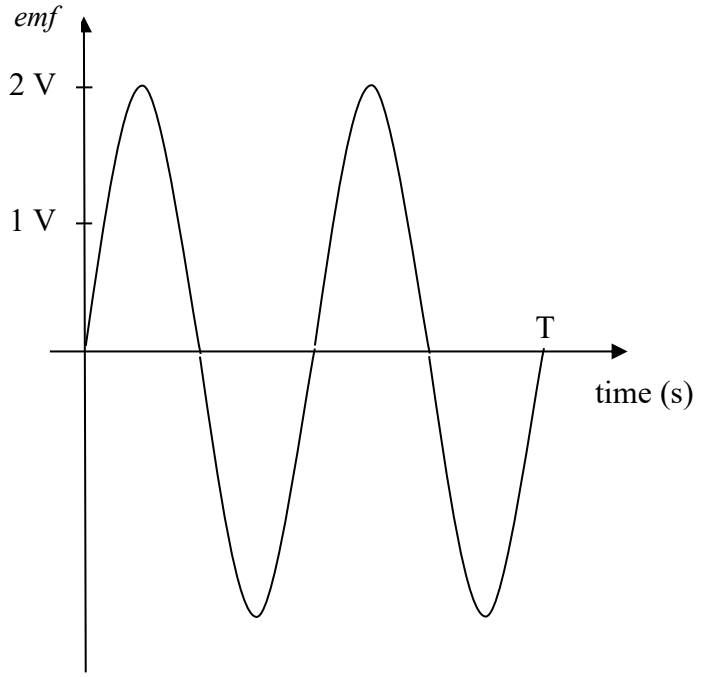
_____

_____

_____

[2 marks]

Using the same wire coil and the same magnetic field, but under different conditions, the following graph was obtained. The same time scale is used as for the original graph and T has the same value as before.



b. Explain the different conditions that could have caused this result.

_____

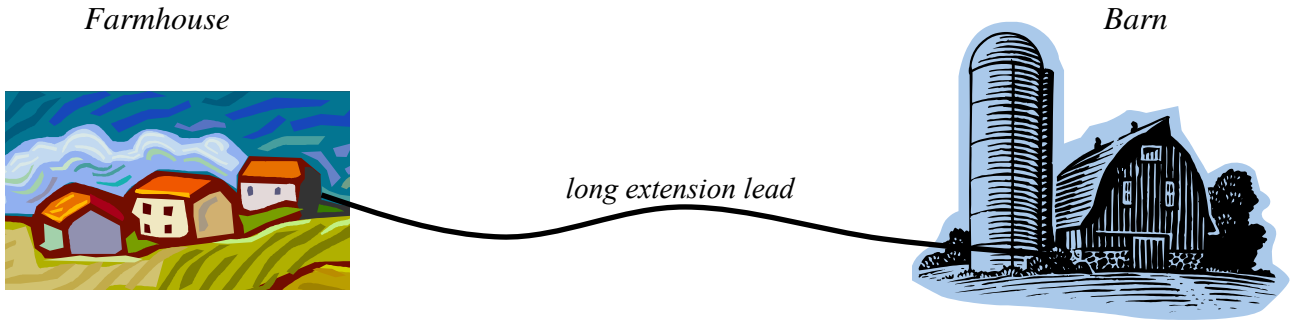
_____

_____

[1 mark]

Question 13 (8 marks)

Gary and his son Toby are farmers who have connected their barn to their farmhouse using a long extension lead. The voltage supplied at the farmhouse is 240 V and they test the voltage power socket in the barn with a voltmeter and find it is 240 V as well.



Unfortunately, when they plug in their milking machine it does not run properly as it only receives 180 V while drawing 3.0 amperes of current.

a. Explain why they originally measured the voltage at 240 V using a voltmeter at the barn but only got 180 V when attempting to run the milking machine.

_____

_____

_____

_____

_____

_____

[2 marks]

b. What is the resistance of the connecting extension lead?

	Ω

[2 marks]

c. Gary says that a second extension lead identical to the first added in parallel to the first will solve the problem of voltage drop while Toby suggests that the only way to get very close to 240 V at the barn is to use a system of step-up then step-down transformers with high turns ratios. Who is correct?

Circle your choice: **Gary** **Toby**

Give reasons for your choice.

_____

_____

_____

_____

_____

_____

_____

_____

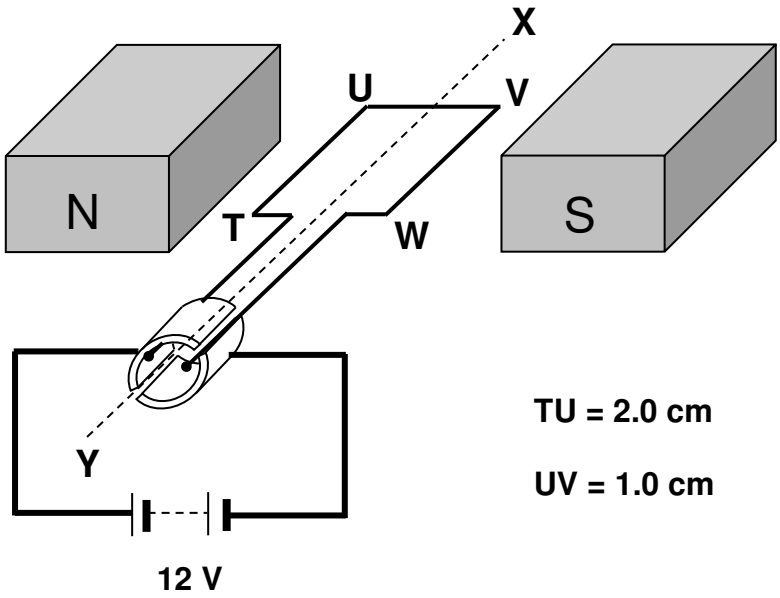
_____

_____

[1 + 3 = 4 marks]

Question 14 (7 marks)

A simplified diagram of a small DC motor is shown below. In this model the single rectangular coil is attached to a commutator and allowed to rotate freely in a uniform magnetic field.



a. On the diagram above, draw the directions of the forces on the side of the coil **TU** and on the side **VW**.

[2 marks]

b. The single coil **TUVW** is carrying a current of 1.5 A. The length of side **TU** is 2.0 cm and experiences a force of 3.0×10^{-4} N. What is the size of the magnetic field strength?

T

[2 marks]

The coil rotates so that side **UV** is vertical to the magnetic field.

c. What is the magnitude of the force on side **UV**?

N

[1 mark]

d. What is the purpose of the 12 V battery in this motor?

_____

_____

_____

_____

[2 marks]

Question 15 (5 marks)

An X-ray source produces X-rays of momentum 5.5×10^{-24} kg m s^{-1}.

a. What is the wavelength of these X-rays?

m

[2 marks]

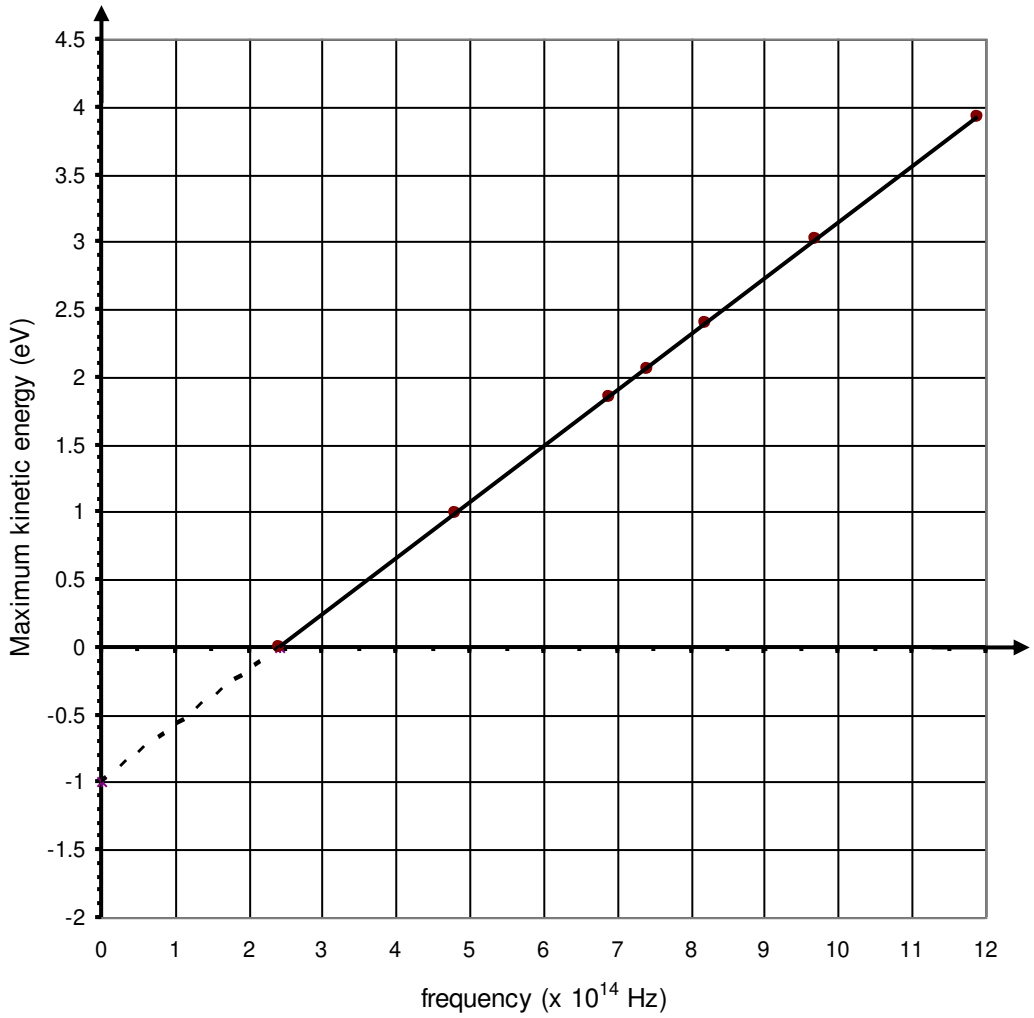
b. What is the energy, in kiloelectron volts (keV), of one of these X-rays?

keV

[3 marks]

Question 16 (7 marks)

Robert Millikan performed an early experiment to investigate the photoelectric effect. The graph below represents the results of one of his experiments. He shone light of different frequencies onto the clean surface of a metal and measured the kinetic energy of the ejected photoelectrons.



a. Use the graph to determine the work function for this metal.

eV

[1 mark]

b. Use the graph to determine the threshold frequency for this metal.

Hz

[1 mark]

c. Use the graph to determine the maximum kinetic energy of the electrons ejected when light of frequency 8.0×10^{14} Hz is shone on the metal.

eV

[1 mark]

d. What is the significance of the gradient of this graph and what numerical value should it be close to? (No calculation required).

_____

_____

[2 marks]

e. Explain why no electrons are ejected at the frequency of 2.0×10^{14} Hz.

_____

_____

_____

_____

[2 marks]

Question 17 (2 marks)

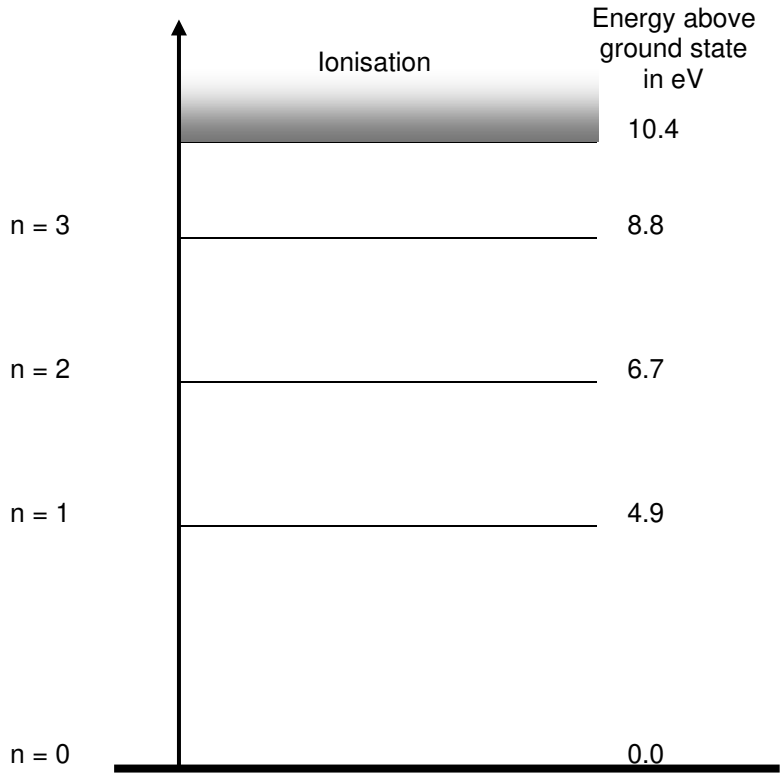
What is the de Broglie wavelength, in nanometres, of an electron moving at a speed of 2.00×10^6 m s^{-1}?

nm

[2 marks]

Question 18 (2 marks)

The following diagram shows the quantised energy levels of a mercury atom, relative to the ground state.



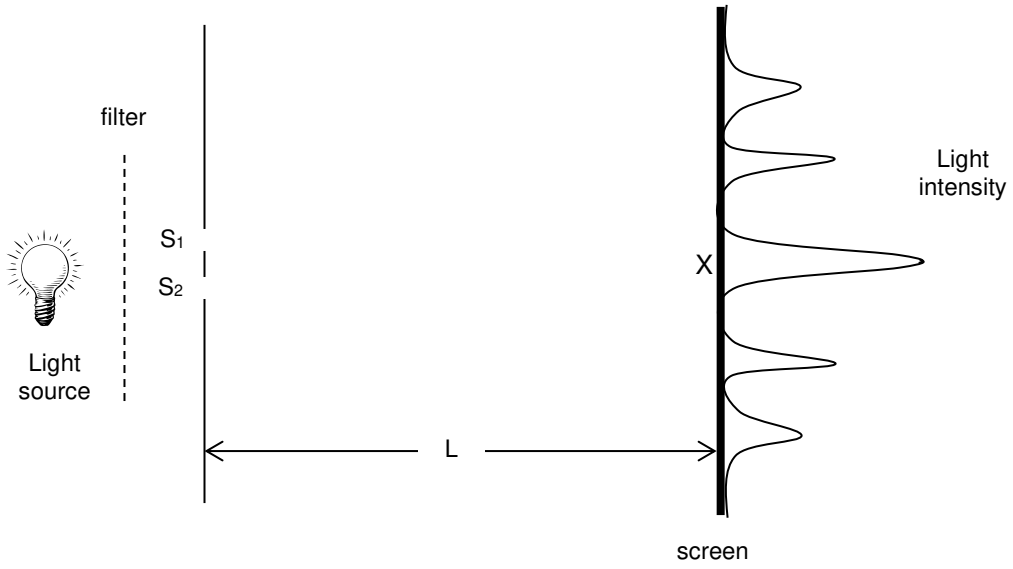
What is the longest wavelength photon that can be emitted when an electron decays from the n = 2 level?

m

[2 marks]

Question 19 (2 marks)

A student sets up a Young's Double Slit experiment in the laboratory. A series of light and dark bands are seen on the screen. The experimental set up is shown below. The light source used in this experiment is filtered to provide monochromatic light.



Explain why there is a bright band at the point X on the screen?

_____

_____

_____

_____

[2 marks]

END OF TRIAL EXAMINATION

Motion and related energy transformations

velocity; acceleration	$v = \frac{\Delta s}{\Delta t}$; $a = \frac{\Delta v}{\Delta t}$
equations for constant acceleration	$v = u + a\,t$ $s = u\,t + \frac{1}{2}\,a\,t^2$ $s = v\,t - \frac{1}{2}\,a\,t^2$ $v^2 = u^2 + 2\,a\,s$ $s = \frac{1}{2}\,(v + u)\,t$
Newton's second law	$\Sigma F = m\,a$
uniform circular motion	$F_{net} = \frac{m\,v^2}{r}$; $v = \frac{2\,\pi r}{T}$
Hooke's law	$F = -k\,x$
elastic potential energy	$E_s = \frac{1}{2}\,k\,x^2$
gravitational potential energy	$E_g = m\,g\,\Delta h$
kinetic energy	$E_k = \frac{1}{2}\,m\,v^2$
Newton's law of universal gravitation	$F = G\,\frac{m_1\,m_2}{r^2}$
gravitational field	$g = G\frac{M}{r^2}$
impulse	$F\,\Delta t = m\,\Delta v$
momentum	$p = m\,v$

Einstein's special theory of relativity

Lorentz factor	$\gamma = \frac{1}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$
time dilation	$t = \gamma\,t_o$
length contraction	$L = \frac{L_o}{\gamma}$
relativistic rest energy	$E_o = m\,c^2$
relativistic total energy	$E_{total} = E_k + E_o = \gamma\,m\,c^2$
relativistic kinetic energy	$E_k = (\gamma - 1)\,m\,c^2$

Fields and application of field concepts

electric field between charged plates	$E = \frac{V}{d}$
energy transformations of charges in an electric field	$\frac{1}{2} m v^2 = q V$
field of a point charge	$E = k \frac{q}{r^2}$
electric force on a charged particle	$F = q E$
Coulomb's law	$F = k \frac{q_1 q_2}{r^2}$
magnetic force on a moving charge	$F = q v B$
magnetic force on a current-carrying conductor	$F = n I l B$
radius of a charged particle in a uniform magnetic field	$r = \frac{m v}{q B}$

Generation and transmission of electricity

current; power	$I = \frac{V}{R}$; $P = V I$
resistors in series	$R_T = R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$
ideal transformer action	$\frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$
AC voltage and current	$V_{RMS} = \frac{1}{\sqrt{2}} V_{peak}$ $I_{RMS} = \frac{1}{\sqrt{2}} I_{peak}$
electromagnetic induction	$\varepsilon = -N \frac{\Delta \Phi_B}{\Delta t}$ $\Phi_B = B_\perp A$
transmission losses	$V_{drop} = I_{line} R_{line}$ $P_{loss} = I^2_{line} R_{line}$

Waves

wave equation	$v = f \lambda$
constructive interference	path difference = $n \lambda$
destructive interference	path difference = $(n + \frac{1}{2}) \lambda$
interference pattern spacing	$\Delta x = \frac{\lambda L}{d}$ when $L >> d$

The nature of light and matter

photoelectric effect	$E_{k\,max} = hf - \phi$
photon energy	$E = hf = \frac{h\,c}{\lambda}$
photon momentum	$p = \frac{h}{\lambda}$
de Broglie wavelength	$\lambda = \frac{h}{p}$

Data

acceleration due to gravity at Earth's surface	$g = 9.81$ m s^{-2}
mass of the electron	$m_e = 9.11 \times 10^{-31}$ kg
magnitude of the charge on the electron	$e = 1.60 \times 10^{-19}$ C
Planck's constant	$h = 6.63 \times 10^{-34}$ J s $\quad h = 4.14 \times 10^{-15}$ eV s
speed of light in a vacuum	$c = 3.00 \times 10^{8}$ m s^{-1}
universal gravitation constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
mass of Earth	$M_E = 5.98 \times 10^{24}$ kg
radius of Earth	$R_E = 6.37 \times 10^{6}$ m
Coulomb constant	$k = 8.99 \times 10^{9}$ N m^2 C^{-2}

Metric (SI) multipliers

p = pico = 10^{-12}	n = nano = 10^{-9}	μ = micro = 10^{-6}	m = milli = 10^{-3}
k = kilo = 10^{3}	M = mega = 10^{6}	G = giga = 10^{9}	T = tera = 10^{12}

Unit conversions

1 tonne (t) = 10^3 kg
1 kilowatt hour (kWh) = 3.6×10^6 J

Nomenclature

force due to gravity	F_g
terminology for force	$F_{on\ A\ by\ B}$
normal force	F_N

END OF FORMULA SHEET

STAV
2024

PHYSICS
Units 3 & 4 Trial Examination
MULTIPLE CHOICE ANSWER SHEET

STUDENT NAME:	

INSTRUCTIONS: **USE PENCIL ONLY**

- Write your name in the space provided above.
- Use a **PENCIL** for **ALL** entries. For each question, **SHADE** the box which indicates your answer.
- Marks will **NOT** be deducted for incorrect answers.
- **NO MARK** will be given if more than **ONE** answer is completed for any question.
- If you make a mistake, **ERASE** the incorrect answer – **DO NOT** cross it out.

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