Pymble Ladies' College

Student Number

2020
TRIAL EXAMINATION

Physics

General Instructions

Reading time - 5 minutes

Working time - 3 hours

Write using black pen

Draw diagrams using pencil

Board-approved calculators may be used

A data sheet, formulae sheets and Periodic Table are provided

Write your Student Number at the top of this page and the multiple choice answer sheet

Total marks – 100

This paper has two parts, Part A and Part B

Part A – 20 marks
- Attempt Questions 1–20
- Allow about 40 minutes for this part

Part B – 80 marks
- Attempt Questions 21–36
- Allow about 2 hours and 20 minutes for this part

PART A

Multiple choice 20 marks
Attempt Questions 1–20.
Allow about 40 minutes for this part

Use the multiple-choice answer sheet attached at the end of this exam paper.

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

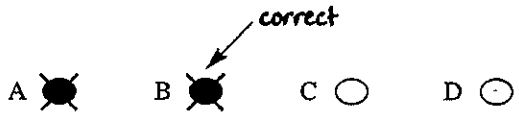
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

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

A ● B ⊗ C ○ D ○

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.



Question 1
Which variable(s) determine the maximum height of a projectile?

A. Launch elevation angle of 45° only

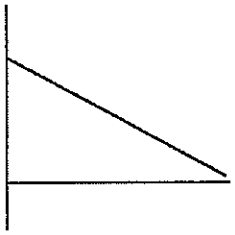
B. Launch speed only

C. Launch speed and launch elevation angle

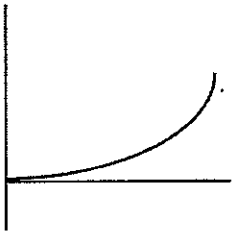
D. Launch speed and range

Question 2
Which graph shows the relationship between the mass and surface gravitational field of planets with the same radius.

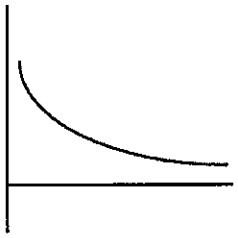
(A)



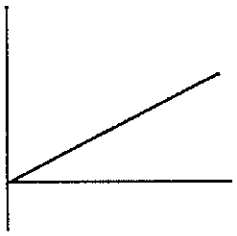
(B)



(C)



(D)



Question 3
Which statement best accounts for the difference between projectile and uniform circular motion?

A. In projectile motion, linear motion is in a constant direction relative to the frame of reference, while in circular motion, it is always changing.

B. In projectile motion, the force is in a constant direction relative to the frame of reference, while in circular motion it is always perpendicular to the velocity of the object undergoing circular motion.

C. In projectile motion, the acceleration is in the same direction as the motion, while in circular motion it is always perpendicular to the motion.

D. In projectile motion, the horizontal velocity is constant, while in circular motion the vertical motion is constant.

Question 4

The diagram shows a worker who is having trouble lifting a heavy box using a lever.

How could she use her strength more effectively?

A. By pushing perpendicularly to the lever at the end of the bar

B. By pushing vertically at the end of the bar

C. By pushing perpendicular to the lever closer to the box

D. By pushing vertically closer to the box

Question 5

The escape velocity of Earth is 11200 ms^{-1} and yet a space craft, moving at much lower speed, can travel away from the Earth and towards distant planets.

Which statement about this is correct?

A. If a space craft turns off its engines, it will slow down and be pulled back to Earth.

B. To escape the Earth's gravitational field, a space craft will have to accelerate to 11200 ms^{-1} at some stage during the trip.

C. A space craft in orbit around the Earth could use engines to accelerate and escape Earth's gravity at a speed lower than 11200 ms^{-1}.

D. The escape velocity depends on the mass of the space craft.

Question 6

Which statement about an induction motor is correct?

A. It has no moving parts.

B. It utilises a rotating magnetic field.

C. It is the only type of motor using AC current.

D. It does not have a current-carrying conductor.

Question 7

What happens to the electric field strength between two parallel plates if the voltage between them is doubled and the distance between them is halved?

A. Electric field strength stays the same.

B. Electric field strength halves.

C. Electric field strength doubles.

D. Electric field strength becomes four times greater.

Question 8

When a charge is accelerated through a potential difference of 500 V, its kinetic energy increases from 2.0×10^{-5} J to 6.0×10^{-5} J. What is the magnitude of the electric charge?

A. 4.0×10^{-8} C

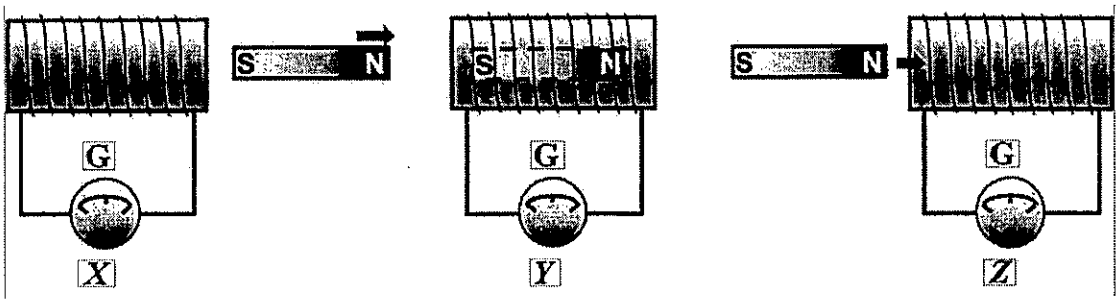
B. 8.0×10^{-8} C

C. 1.2×10^{-7} C

D. 1.6×10^{-7} C

Question 9

A single magnet moves from left to right at a constant speed through three identical coils – X, Y and Z. Each coil has a corresponding galvanometer to detect the current. Three instances of its journey are shown in the diagram.

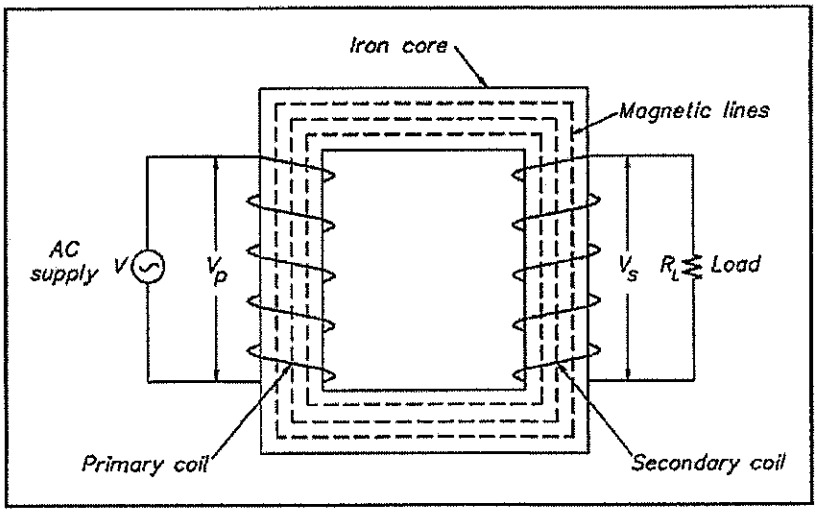


Which choice correctly shows the relationship between the needle position on each galvanometer?

	Galvanometer X (coil moving away)	Galvanometer Y (coil within)	Galvanometer Z (coil moving towards)
A.	↖	↖	↖
B.	↗	↗	↗
C.	↗	↑	↗
D.	↖	↑	↗

Question 10

A student designed and built a step-up transformer as part of her practical work and included the diagram below of her design in the written report.



Which statement is a correct evaluation of her experimental design?

A. The design is correct because the output voltage will be larger than the input voltage.

B. The design is incorrect because the windings of the coils are drawn in opposite directions.

C. The design is incorrect because it represents a step-down transformer.

D. The design is incorrect because it has equal numbers of turns in both coils.

Question 11

Friction braking on cars obeys the law of Conservation of Energy by generating heat energy from the car's kinetic energy.

Which of the following is generated with magnetic braking to ensure the same law is obeyed?

A. Elastic potential energy
B. Magnetic fields
C. Eddy currents and heat energy
D. Gravitational potential energy

Question 12

How did Newton's particle theory of light explain refraction?

A. Stronger forces within the refracting medium changed the direction of travel of the light particles as they entered the medium.

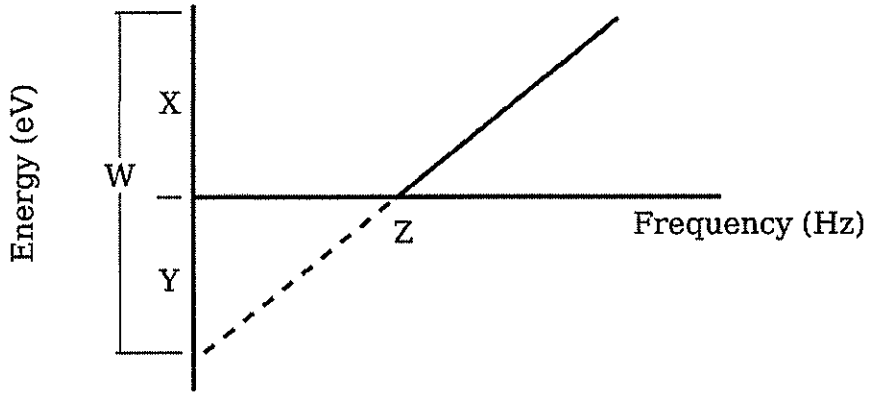
B. Because the refracting medium was so dense compared to air, the light particles were forced to slow down.

C. The light particles scattered in the medium because the medium particles were closer together than air particles.

D. Newton's particle theory of light could not explain refraction.

Question 13

The graph shows information about the emission of photoelectrons from a metal.



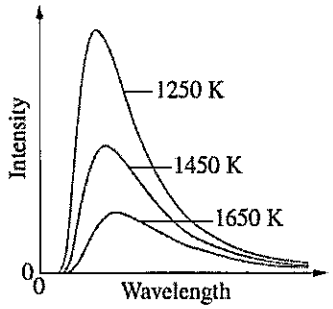
Which choice correctly identifies the sections labelled W, X, Y and Z?

	W	X	Y	Z
A.	Energy of incident photon	Work function of emitter	Kinetic energy of emitted photoelectron	Threshold frequency
B.	Kinetic energy of emitted photoelectron	Energy of incident photon	Threshold frequency	Work function of emitter
C.	Threshold energy	Kinetic energy of emitted photoelectron	Energy of incident photon	Work function of emitter
D.	Energy of incident photon	Kinetic energy of emitted photoelectron	Work function of emitter	Threshold frequency

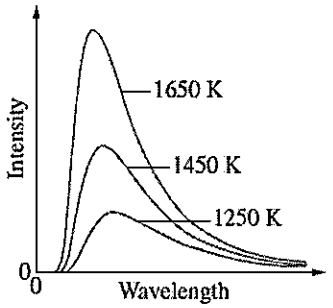
Question 14

Which graph is consistent with predictions resulting from Planck's hypothesis regarding radiation from black bodies?

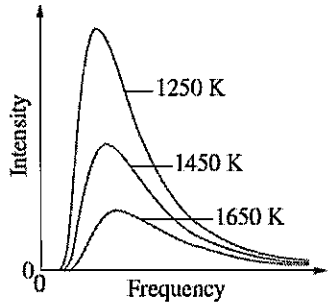
A.



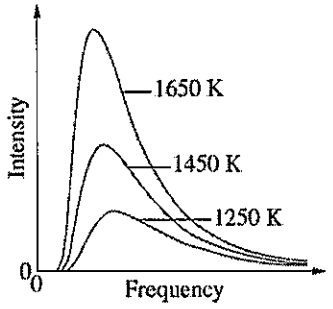
B.



C.

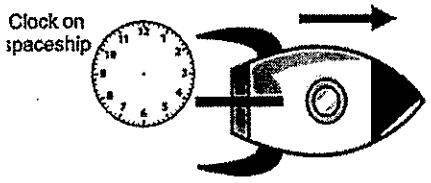


D.

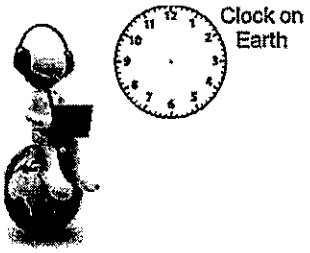


Question 15

The diagram below shows a spaceship moving past the Earth close to the speed of light. An observer on Earth observes time on his clock and on the clock of the spaceship.



Spaceship moving past the Earth

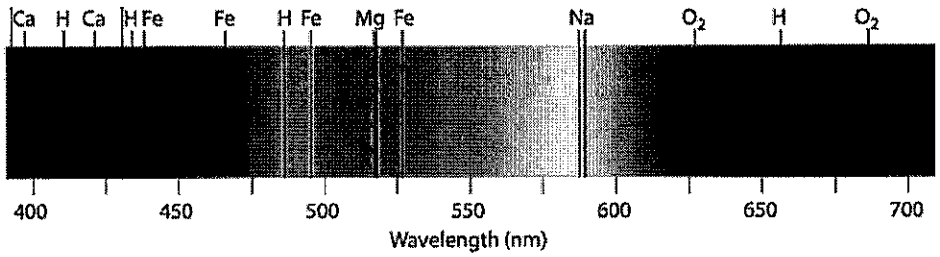


Which statement about this situation is correct?

A. The clock on the ship will run slower.
B. The clock on the ship will run faster.
C. The clock on Earth will run faster.
D. The clock on Earth will run slower.

Question 16

An absorption spectrum from a star is shown.



What is indicated by the existence of the dark lines in the spectrum?

A. the star is moving away from us.

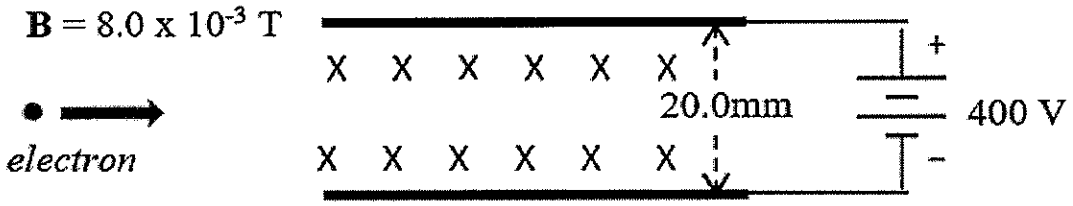
B. atoms in the star's atmosphere are absorbing light and not re-emitting it.

C. several elements are present in the star's atmosphere.

D. only some atoms in the star's atmosphere are contributing to the spectrum.

Question 17

An electron enters a region where a uniform magnetic field is perpendicular to an electric field between two charged plates, as shown.



The electron passes through the crossed fields without being deflected.

The electron's speed is:

A. 8.0×10^{-15} m s^{-1}

B. 1.6×10^{3} m s^{-1}

C. 5.0×10^{4} m s^{-1}

D. 2.5×10^{6} m s^{-1}

Question 18

Step-down transformers are used in the distribution of energy.

Which statement about their use is correct?

A. They ensure low power loss in transmission lines.

B. They have laminated cores to ensure complete flux linkage.

C. They enable safe voltages to be delivered to consumers.

D. They reduce the current flowing in transmission lines.

Question 19

Laser light with a wavelength of 621 nm was passed through a double slit. The two slits are 100 μm apart.

The resulting interference pattern is reproduced below. The screen is placed 1.50 m from the slits.

NOT TO SCALE

What is the distance from the central maximum to the 2nd bright spot on the screen?

A. 19 mm

B. 15 mm

C. 12 mm

D. 3.0 mm

Question 20

In 2012 scientists at the European Organisation for Nuclear Research (CERN) in Switzerland claimed to have found the Higgs boson. They measured its rest energy as 126 GeV. If this measurement is correct, the mass of the Higgs boson is closest to:

A. 1.40×10^{-9} kg.

B. 2.24×10^{-24} kg.

C. 2.24×10^{-25} kg.

D. 1.40×10^{-24} kg.

Part B Extended Answers – 80 marks

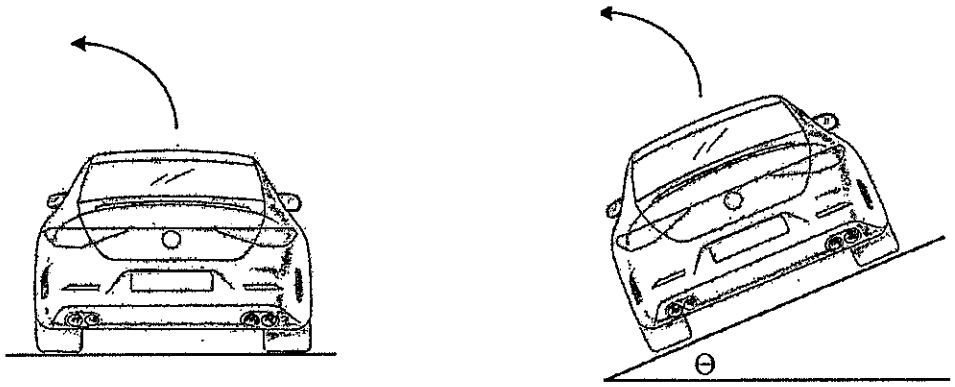
Attempt Questions 21 – 36

Allow about 2 hours and 20 minutes for this part
Answer the questions in the spaces provided. Extra Space is provided at the end of the exam if required.

Show all relevant working in questions involving calculations.

Question 21 (4 marks)

The diagram shows identical cars on rough road surfaces, one on a curved horizontal road and one on a curved road banked at 8°. The cars are viewed from behind. Both roads curve towards the left and have the same radius.



With the help of annotations to the diagram above, explain why the car can safely take the banked curve at a higher speed than the identical car driving on the horizontal curved road. **4**

Question 22 (7 marks)

A stroboscopic photograph was taken of an athlete competing in a long jump event. The distance between the athlete in the first and last images is 7.4 m. The camera used to take the pictures took one frame every 0.1 s. The parallax error is **not** significant in making accurate measurements.

Using appropriate equations, calculate the maximum height and launch velocity. Clearly identify any assumptions you have made. 7

Question 22 continues over page

Question 22 (continued)

Question 23 starts over the page

Question 23 (3 marks)

A 2500 kg satellite is launched from a place on the Earth's surface where it has a rotational speed of 370 m/s.
It is then launched into a circular orbit with a radius of 2.0×10^7 m.

What amount of work is required to place this satellite into its orbit? **4**

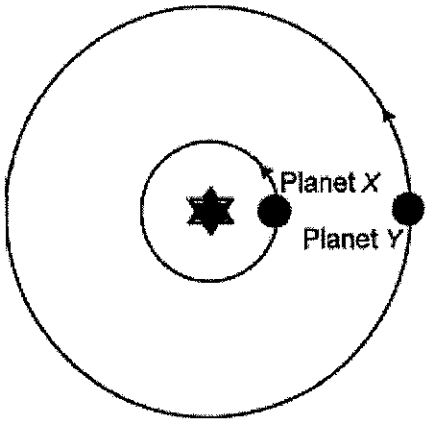
Question 24 starts over the page

Question 24 (3 marks)

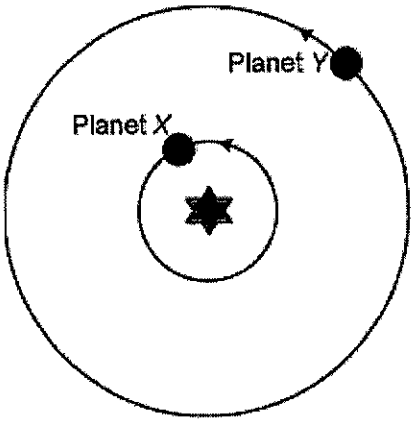
Two planets, X and Y, travel anticlockwise in circular orbits about a star, as seen in the diagram. The radii of the orbits X and Y are in the ratio 2:5.

The planets are shown below at a time interval of 5 years. Initially they were aligned, making a straight line with the star. Five Earth years later, planet X has rotated through 120° (1/3 of a revolution) as shown.

Initial Position of planets



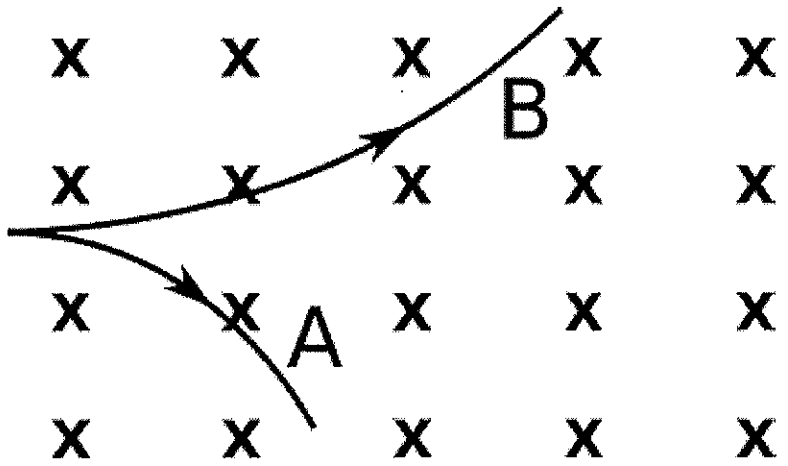
Position of planets 5 years later



Determine how long it takes (in Earth years) for planet Y to orbit the star. **3**

Question 25 (5 marks)

Charged particles A and B move into a magnetic field and move along different circular paths as shown in the diagram.

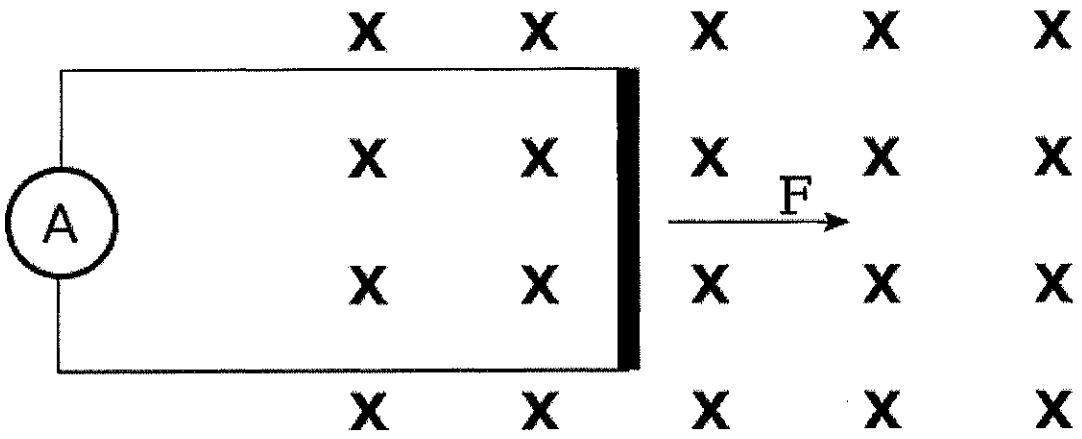


a) What **must** be different about particles A and B? Justify your answer. **2**

b) What **might** be different about particles A and B? Justify your answer. **3**

Question 26 (4 marks)

A conductor which is connected to a galvanometer is moved by a force F through a magnetic field, as shown below.



In terms of the principles of physics involved, show on the diagram the direction of the induced current in the conductor and explain why it must be in this direction. **4**

Question 27 (4 marks)

One definition of the ampere states:

The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed one metre apart in vacuum, would produce a force equal to 2×10^{-7} *newtons per metre of length between these conductors.*

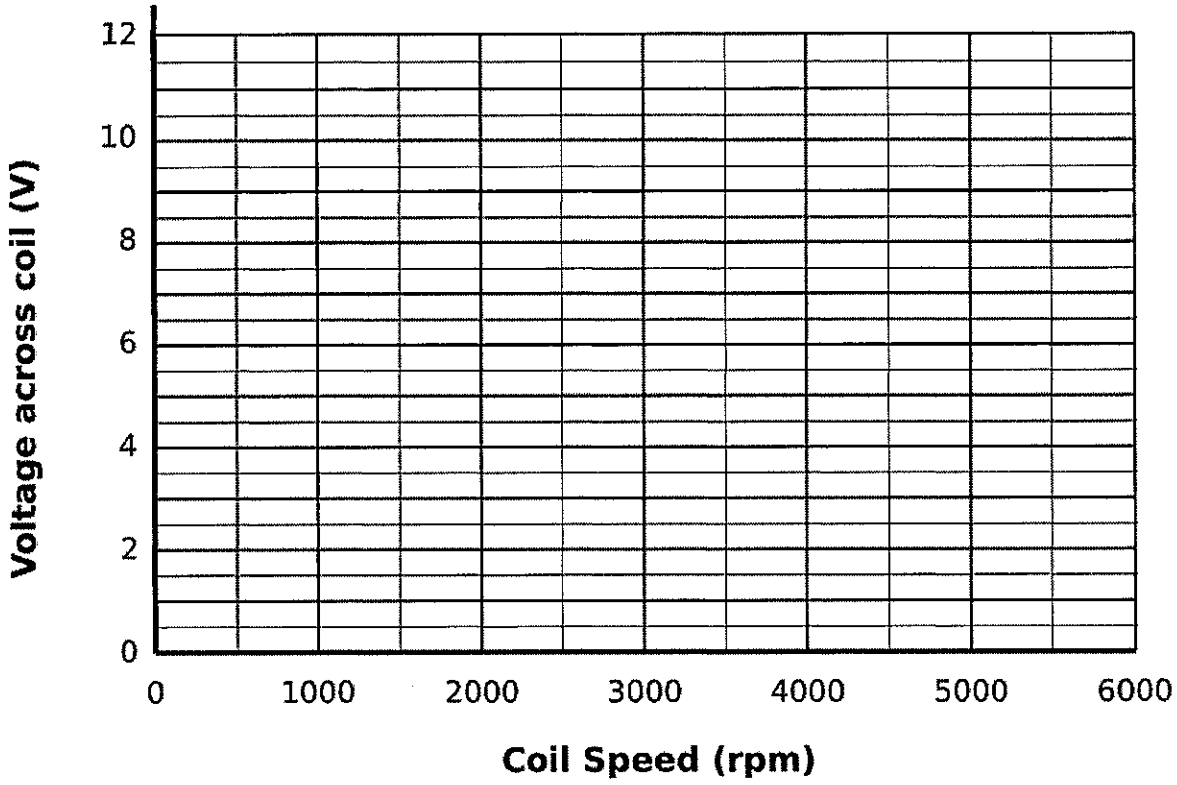
Explain how this definition of the ampere relates to Newton's Third Law and calculate the size of the force between two parallel current carrying wires, each 0.65 metres long, carrying 0.375 amperes each, and separated by a distance of 13.5 mm. **4**

Question 28 (8 marks)

The table shows the results of an experiment on the relationship between the rotational speed in revolutions per minute (rpm) of a motor coil and the net voltage across the coil. The motor was connected to a 12 V power supply. Assume that there is a load attached to the motor.

Speed of coil (rpm)	*Voltage across coil (V)*
0	12.0
500	10.6
1000	8.2
1500	7.6
2000	6.6

(a) Plot this data on the axes below. **1**



Question 28 continues over the page

Question 28 (continued)

(b) Explain why the net voltage across the coil decreases as the speed of the motor increases, **and** why the voltage across the coil will not reach zero. **5**

(c) **On the same axes where you plotted the data,** draw and extrapolate the curve of best fit to show the relationship between the voltage across the coil and the coil speed for speeds of 0 to 6000 rpm. **2**

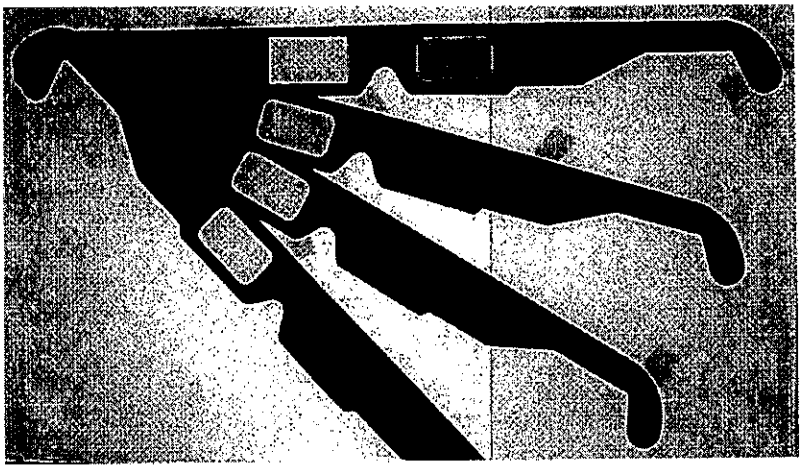
Question 29 (8 marks)

Outline the contribution of James Maxwell to our understanding of the nature of light and outline the experimental evidence, found soon after his death, that supported Maxwell's theory. **8**

Question 30 (4 marks)

The photograph below shows the two lenses of a pair of cardboard glasses that have been opened flat. Both lenses are in front of the same polarised light source. The arm of the glasses is pivoted on the left-hand side so that the angle of the arm relative to the light source can be changed.

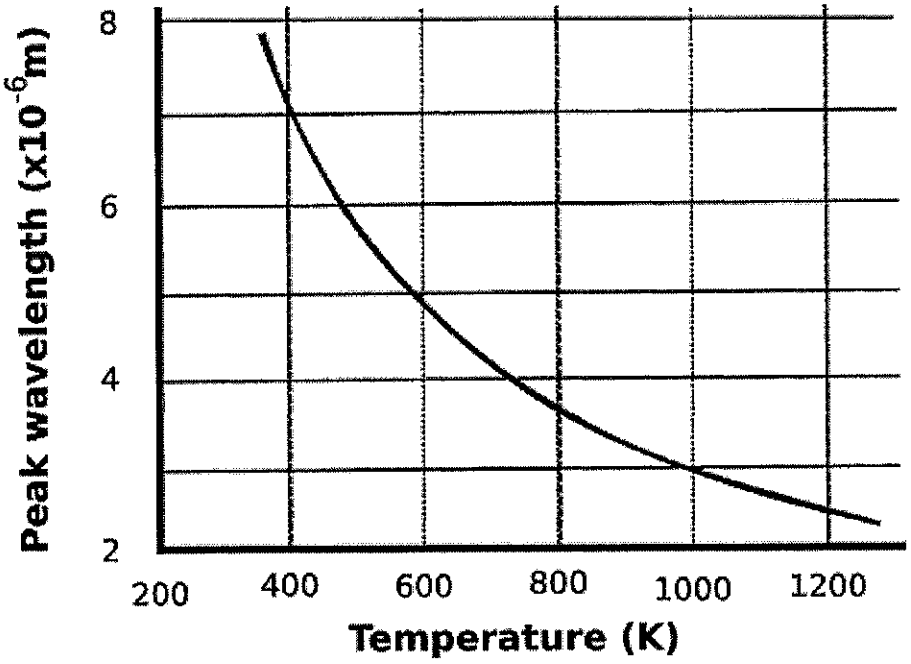
The photograph below shows the two lenses at four different positions.



In terms of the principles of physics involved, account for the lack of change in the light passing through the left-hand lens compared to the changing amount of light passing through the right-hand lens as the angle of rotation of the lenses is increased. **4**

Question 31 (4 marks)

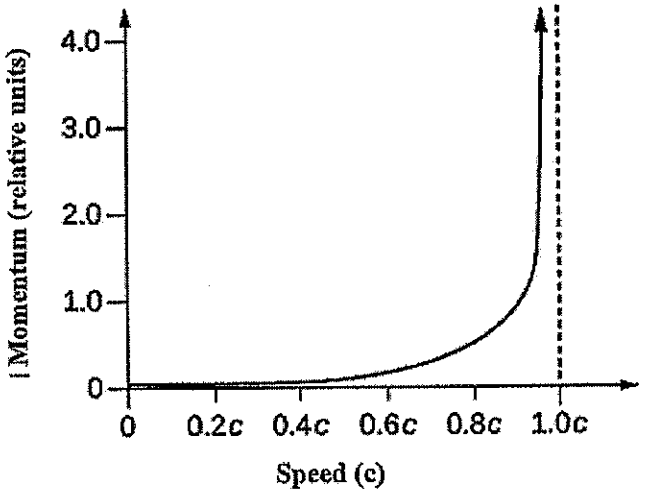
The graph below shows the wavelength of the peak intensity radiation emitted by a standard black body at different surface temperatures.



Show that this graph is consistent with Wien's law. **4**

Question 32 (5 marks)

The diagram shows how the momentum of an object changes as it approaches light speed.



a) Explain why this graph is not a straight line as classical theory would predict. **3**

b) Calculate the relativistic momentum of a proton moving at 0.8 c. **2**

Question 33 (9 marks)

a) Outline, with the aid of a diagram a thought experiment that relates to the prediction of length contraction. **3**

Muons are created a distance of 10.0 km above the Earth's surface as measured by an observer on Earth's surface. They then travel vertically downwards to the surface where they are detected.

b) Calculate the distance for this journey as measured by the muons. **3**

Question 33 continues over the page

Question 33 (continued)

c) Explain how investigations involving muons provided experimental validation of length contraction. **3**

Question 34 starts over the page

Question 34 (4 marks)

Compare the effects of electric and magnetic fields on a charged particle if the particle is initially moving perpendicular to the fields. Support your answer with a labelled diagram showing each field. **4**

Question 35 starts over the page

Question 35 (7 marks)

Ultraviolet light with a wavelength of 180 nm is shone on a polished nickel plate which has a work function of 5.01 eV.

a) Determine the maximum kinetic energy of the electrons emitted from the surface of the nickel plate. **3**

b) Describe the interaction of radiation with matter that describes the photoelectric effect. **4**

~ END OF EXAM ~

Part B extra writing space

If you use this space, clearly indicate which questions you are answering.

Part B extra writing space

If you use this space, clearly indicate which questions you are answering.

Pymble Ladies' College

2020

Physics – Multiple Choice Answer Sheet

Student Number:

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

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PART A

Multiple choice 20 marks
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A ○ B ● C ○ D ○

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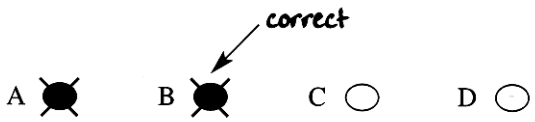


Question 1
Which variable(s) determine the maximum height of a projectile?

A. Launch elevation angle of 45^{o} only

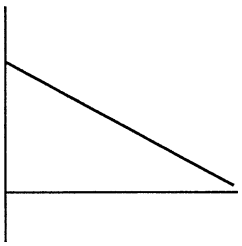
B. Launch speed only

C. Launch speed and launch elevation angle

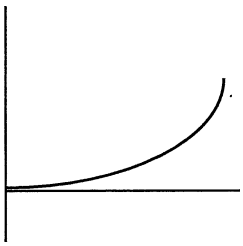
D. Launch speed and range

Question 2
Which graph shows the relationship between the mass and surface gravitational field of planets with the same radius.

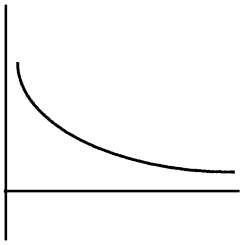
(A)



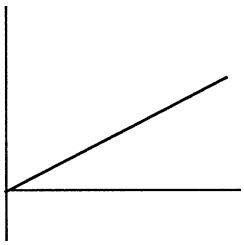
(B)



(C)



(D)



Question 3
Which statement best accounts for the difference between projectile and uniform circular motion?

A. In projectile motion, linear motion is in a constant direction relative to the frame of reference, while in circular motion, it is always changing.

B. In projectile motion, the force is in a constant direction relative to the frame of reference, while in circular motion it is always perpendicular to the velocity of the object undergoing circular motion.

C. In projectile motion, the acceleration is in the same direction as the motion, while in circular motion it is always perpendicular to the motion.

D. In projectile motion, the horizontal velocity is constant, while in circular motion the vertical motion is constant.

Question 4

The diagram shows a worker who is having trouble lifting a heavy box using a lever.

How could she use her strength more effectively?

A. By pushing perpendicularly to the lever at the end of the bar

B. By pushing vertically at the end of the bar

C. By pushing perpendicular to the lever closer to the box

D. By pushing vertically closer to the box

Question 5

The escape velocity of Earth is 11200 ms^{-1} and yet a space craft, moving at much lower speed, can travel away from the Earth and towards distant planets.

Which statement about this is correct?

A. If a space craft turns off its rockets, it will slow down and be pulled back to Earth.

B. To escape the Earth's gravitational field, a space craft will have to accelerate to 11200 ms^{-1} at some stage during the trip.

C. A space craft in orbit around the Earth could use rockets to accelerate and escape Earth's gravity at a lower speed **than 11200 ms^{-1}**

D. The escape velocity depends on the mass of the space craft.

Question 6

Which statement about an induction motor is correct?

A. It has no moving parts.

B. It utilises a rotating magnetic field.

C. It is the only type of motor using AC current.

D. It does not have a current-carrying conductor.

Question 7

What happens to the electric field strength between two parallel plates if the voltage between them is doubled and the distance between them is halved?

A. Electric field strength stays the same.

B. Electric field strength halves.

C. Electric field strength doubles.

D. Electric field strength becomes four times greater.

Question 8

When a charge is accelerated through a potential difference of 500 V, its kinetic energy increases from 2.0×10^{-5} J to 6.0×10^{-5} J. What is the magnitude of the electric charge?

A. 4.0×10^{-8} C

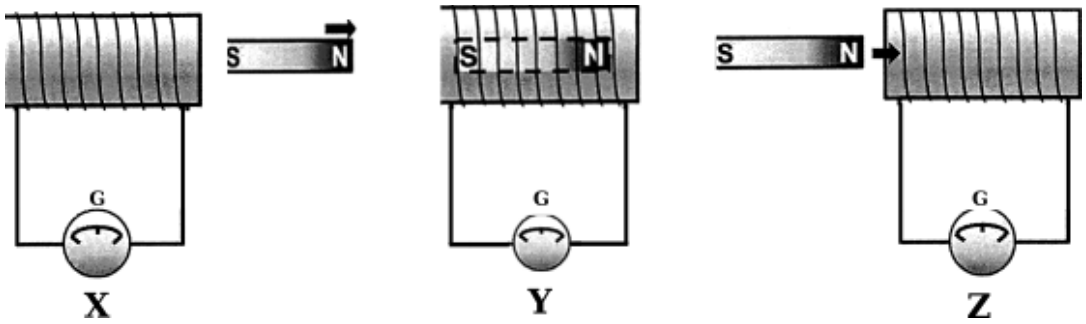
B. 8.0×10^{-8} C

C. 1.2×10^{-7} C

D. 1.6×10^{-7} C

Question 9

A single magnet moves from left to right at a constant speed through three identical coils – X, Y and Z. Each coil has a corresponding galvanometer to detect the current. Three instances of its journey are shown in the diagram.

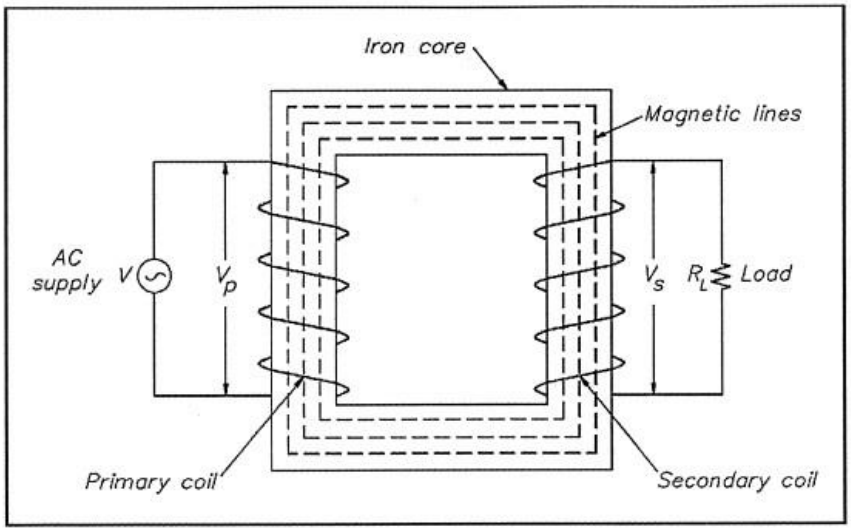


Which choice correctly shows the relationship between the readings on each galvanometer?

	Galvanometer X (coil moving away)	Galvanometer Y (coil within)	Galvanometer Z (coil moving towards)
A.	↖	↖	↖
B.	↗	↗	↗
C.	↗	↑	↗
D.	↖	↑	↗

Question 10

A student designed and built a step-up transformer as part of her practical work and included the diagram below of her design in the written report.



Which statement is a correct evaluation of her experimental design?

A. The design is correct because the output voltage will be larger than the input voltage.

B. The design is incorrect because the windings of the coils are drawn in opposite directions.

C. The design is incorrect because it represents a step-down transformer.

D. The design is incorrect because it has equal numbers of turns in both coils.

Question 11

Friction braking on cars obeys the law of Conservation of Energy by generating heat energy from the car's kinetic energy.

With magnetic braking, the same law is obeyed by the generation of:

A. Elastic potential energy
B. Magnetic fields
C. Eddy currents and heat energy
D. Gravitational potential energy

Question 12

How did Newton's particle theory of light explain refraction?

A. Stronger forces within the refracting medium changed the direction of travel of the light particles as they entered the medium.

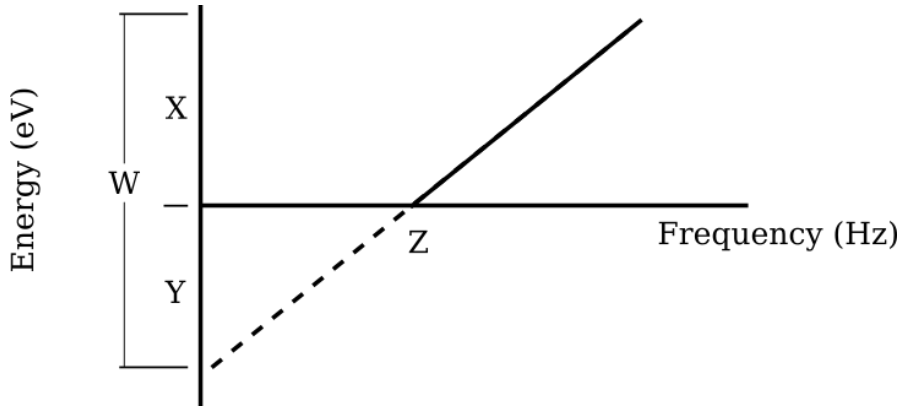
B. Because the refracting medium was so dense compared to air, the light particles were forced to slow down.

C. The light particles scattered in the medium because the medium particles were closer together than air particles.

D. Newton's particle theory of light could not explain refraction.

Question 13

The graph shows information about the emission of photoelectrons from a metal.



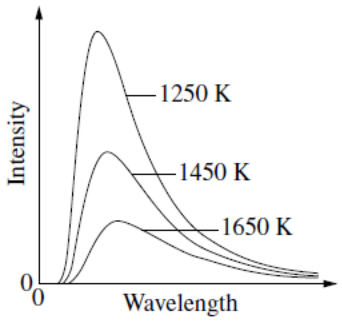
Which choice correctly identifies the sections labelled W, X, Y and Z?

	W	X	Y	Z
A.	Energy of incident photon	Work function of emitter	Kinetic energy of emitted photoelectron	Threshold frequency
B.	Kinetic energy of emitted photoelectron	Energy of incident photon	Threshold frequency	Work function of emitter
C.	Threshold energy	Kinetic energy of emitted photoelectron	Energy of incident photon	Work function of emitter
D.	Energy of incident photon	Kinetic energy of emitted photoelectron	Work function of emitter	Threshold frequency

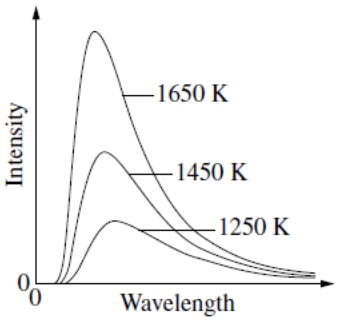
Question 14

Which graph is consistent with predictions resulting from Planck's hypothesis regarding radiation from ~~hot objects~~ black bodies?B

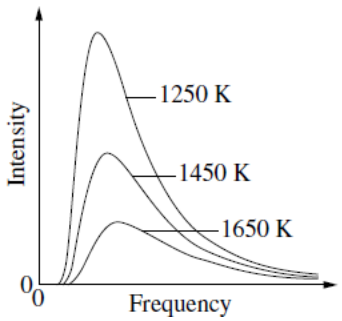
A.



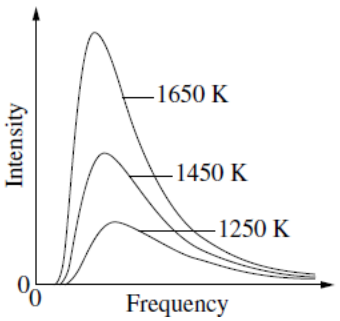
B.



C.

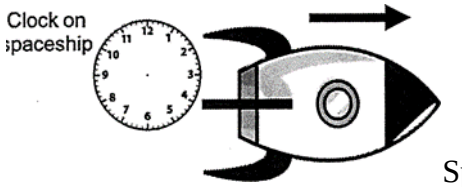


D.

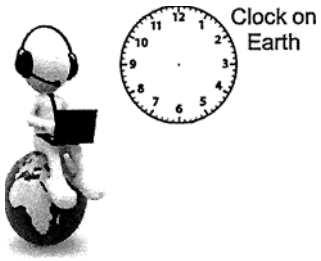


Question 15

The diagram below shows an observer on Earth observing time on his clock and on the clock of a spaceship which is moving past him close to the speed of light.



Spaceship moving past the Earth

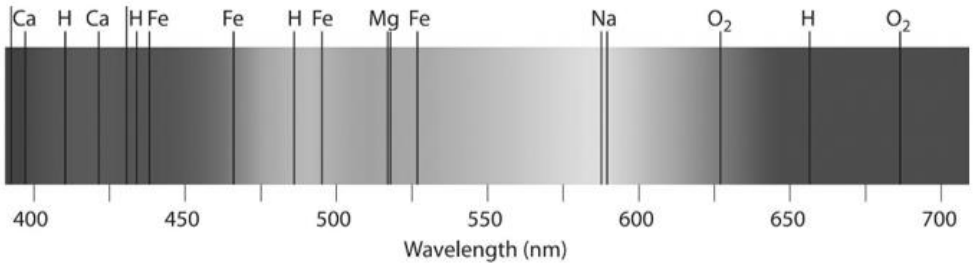


Which statement about this situation is correct?

A. The clock on the ship will run slower.
B. The clock on the ship will run faster.
C. The clock on Earth will run faster.
D. The clock on Earth will run slower.

Question 16

An absorption spectrum from a star is shown.



The dark lines in the spectrum indicate that:

A. the star is moving away from us.

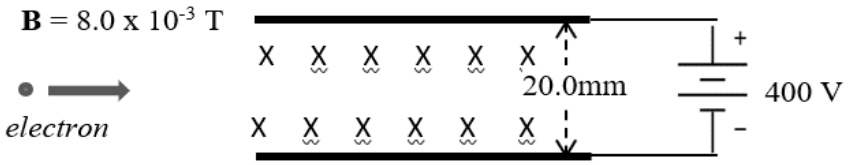
B. atoms in the star's atmosphere are absorbing light and not re-emitting it.

C. several elements are present in the star's atmosphere.

D. only some atoms in the star's atmosphere are contributing to the spectrum.

Question 17

An electron enters a region where a uniform magnetic field is perpendicular to an electric field between two charged plates, as shown.



The electron passes through the crossed fields without being deflected.

The electron's speed is:

A. 8.0×10^{-15} m s^{-1}

B. 1.6×10^{3} m s^{-1}

C. 5.0×10^{4} m s^{-1}

D. 2.5×10^{6} m s^{-1}

Question 18

Step-down transformers are used in the distribution of energy.

Which statement about their use is correct?

A. They ensure low power loss in transmission lines.

B. They have laminated cores to ensure complete flux linkage.

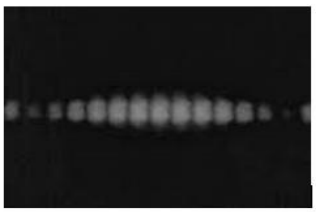
C. They enable safe voltages to be delivered to consumers.

D. They reduce the current flowing in transmission lines.

Question 19

Laser light with a wavelength of 621 nm was passed through a double slit. The slits are 100 μm apart.

The resulting interference pattern is reproduced below. The screen is placed 1.50 m from the slits.



NOT TO SCALE

What is the distance from the central maximum to the 2nd bright spot on the screen?

A. 19 mm

B. 15 mm

C. 12 mm

D. 3.0 mm

Question 20

In 2012 scientists at the European Organisation for Nuclear Research (CERN) in Switzerland claimed to have found the Higgs boson. They measured its rest energy as 126 GeV. If this measurement is correct, the mass of the Higgs boson is closest to:

A. 1.40×10^{-9} kg.

B. 2.24×10^{-24} kg.

C. 2.24×10^{-25} kg.

D. 1.40×10^{-24} kg.

Part B Extended Answers – 80 marks

Attempt Questions 21 – 36

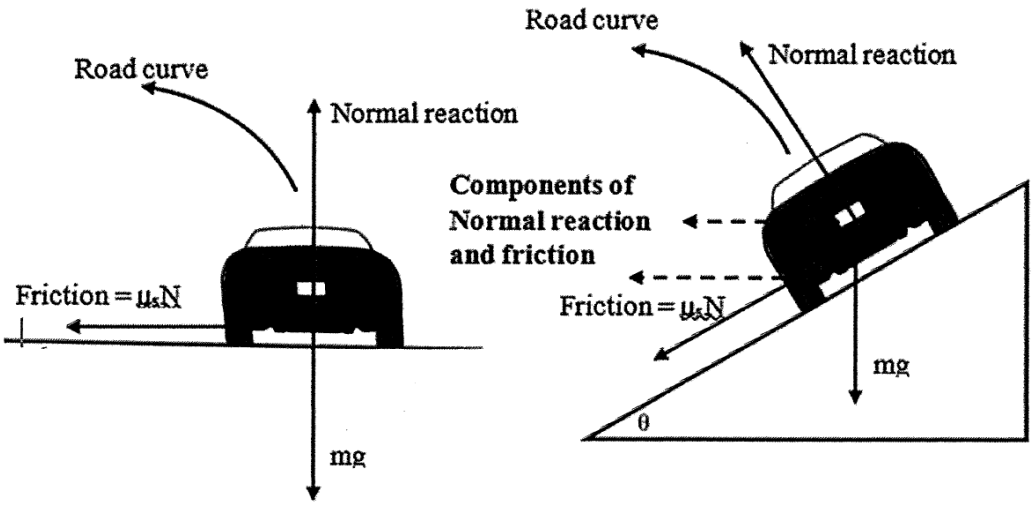
Allow about 2 hours and 20 minutes for this part
Answer the questions in the spaces provided. Extra Space is provided at the end of the exam if required.

Show all relevant working in questions involving calculations.

Question 21 (4 marks)

Criteria	**Marks**
Draw ALL forces acting on the car, showing: • the friction force with identical magnitude in both diagram and parallel to the road • the normal force normal to the road in both diagram • gravity identical in both diagram vertical downward • The net force centripetal and with a greater magnitude for the banked road. Show that on the banked road a greater net force is achieved with the same static friction. Relate the net centripetal force to the speed stating the same radius.	**4**
Draw the normal force and the static friction force with the correct directions in both diagrams. Identify the contribution of the normal force and the static friction force to the centripetal force.	**3**
Draw the normal force with the correct direction in both diagrams. Identify the contribution of the normal force to the centripetal force.	**2**
Draw the friction force parallel to the road and relate the friction force to the centripetal force.	**1**

Sample answer:



On the horizontal road, the friction alone provides the centripetal force to hold car in curve. On the banked road, only a component of the frictional force is acting horizontally but the horizontal component of the normal reaction force contributes. This is significantly larger than the reduction in the frictional force towards the centre of the motion. Therefore, the net centripetal force is larger and since mass and radius of curvature are the same, the car can go faster around the banked curve.

Question 22 (7 marks)

Criteria	**Mark**
All assumptions clearly communicated and reasonable (definition of maximum height, launch angle, time of flight,…). Time of flight correctly assumed. Equations clearly identified and appropriately used using the assumption. Correct calculation of both the maximum height and the initial velocity (magnitude and directions) and results clearly communicated. Working and strategy clearly communicated.	7
Time of flight incorrectly assumed. All other assumptions identified and communicated. Equations clearly identified and appropriately used using the assumptions. Correct calculations for both the maximum height and the initial velocity and results clearly communicated. Working and strategy clearly communicated.	6
Equations clearly identified. Assumption of time of flight inappropriately used in the equations. Overall satisfactory strategy to conduct calculations for both the maximum height and the initial velocity and results clearly communicated. Working and strategy clearly communicated. OR Equations clearly identified.	5

Assumption of time of flight appropriately used in the equations. Overall satisfactory strategy to conduct calculations for both the maximum height and the initial velocity and results communicated partially (velocity). Working and strategy clearly communicated.	
Assumption of time of flight inappropriately used in the equations. Equation clearly identified. Coherent attempt for calculation of initial velocity and results clearly communicated with a mistake on the vertical component. Working and strategy clearly communicated.	4
Time of flight incorrectly assumed and other assumption missing. Equations clearly identified Correct use of equations and strategy attempted.	3
Time of flight assumed. Horizontal component of the velocity correctly calculated.	2
Some relevant assumptions	1

Question 23 (3 marks)

Criteria	**Mark**
• Apply the conservation of energy by showing that the work done is the difference of mechanical energy between the energy when in orbits and the energy at the surface of the earth. • Derive a relationship between the work and the data provided by appropriately stating the definition of potential energy and Kinetic energy and deriving a relationship between the speed and the radius of the orbit.	4

• Work towards a correct calculation. • Express the result scientifically.	
• Apply the conservation of energy by showing that the work done is the difference of mechanical energy between the energy when in orbits and the energy at the surface of the earth. • Derive a relationship between the work and the data provided by appropriately stating the definition of potential energy and Kinetic energy. • Show coherent working.	3
• Apply the conservation of energy by showing that the work done is the difference of mechanical energy between the energy when in orbits and the energy at the surface of the earth. • Show coherent working.	2
• Apply the conservation of energy by showing that the work done is the difference of mechanical energy between the energy when in orbits and the energy at the surface of the earth.	1

Let's consider the energy of the satellite before the launch:

$$E_{surface} = \frac{1}{2}mv_{surface}^2 - G\frac{mM_{Earth}}{R_{Earth}}$$

Let's consider the energy of the satellite in orbit:

$$E_{orbit} = \frac{1}{2}mv_{orbit}^2 - G\frac{mM_{Earth}}{R_{orbit}}$$

By Kepler Law $\frac{R_{orbit}^3}{T^2} = \frac{GM_{Earth}}{4\pi^2}$

Considering the motion to be circular $v_{orbit} = \frac{2\pi}{R_{orbit}}$

$$\therefore E_{orbit} = -G\frac{mM_{Earth}}{2R_{orbit}}$$

By the law of conservation of energy

$$W_{done} = E_{orbit} - E_{surface} = m\left[GM_{Earth}\left(\frac{1}{R_{Earth}} - \frac{1}{R_{orbit}}\right) - \frac{1}{2}v_{surface}^2\right] = 1.3 \times 10^{11} J$$

Question 24 (3 marks)

Criteria	Marks
• Calculates period of planet X. • State the ratio of the radii.	3

• Calculates period of planet Y by applying Kepler's Law using the period of planet X and the ratio of the radii.	
• States Kepler's Law. • Calculates period of planet X.	2
• Calculates period of planet X.	1

Sample answer

$$T_x = 3 \times 5y = 15y$$

$$\frac{r_x}{r_y} = \frac{2}{5}$$

By Kepler's Law $\frac{T_x^2}{r_x^3} = \frac{T_y^2}{r_y^3} \therefore T_y = 15\sqrt{\frac{5^3}{2^3}} = 59y$

Question 25a (2 marks)

Criteria	Marks
• Identifies signs of charge with justification.	2
• Identifies difference in charge OR • Identifies signs of charge with no justification.	1

Sample answer:

The signs of the charges of the particles must be different (A is negative and B positive) because their trajectory curve in opposite directions within the field.

Question 25b (3 marks)

Criteria	Marks
• Derives $r = \frac{mv}{qB}$. • Identifies 2 possible differences with justification.	3
• State $F_c = \frac{mv^2}{r}$ • Identify mass and velocity as possible differences. OR • Derives $r = \frac{mv}{qB}$. • Identifies 1 possible differences with justification.	2
• Identifies 1 possible difference.	1

Sample answer:

The motion of a charged particle, entering a magnetic field with a velocity parallel to the field lines, is is circular uniform as the magnetic force is centripetal.

Hence, $qvB = \frac{mv^2}{r} \therefore r = \frac{mv}{qB}$.

Consequently, as the radius are different, the speed, the value of the charge or the mass might be different.

Question 26 (4 marks)

Criteria	Marks
• Draw a correct direction for the induced current on the diagram. • Identifies an increase in magnetic flux. • Justify the direction of the induced current by referring to the Lenz Law. • Relate the Lenz law to the conservation of energy in this context.	3-4
• Draw a correct direction for the induced current on the diagram. • Identifies an increase in magnetic flux. • Justify the direction of the induced current by referring to the Lenz Law OR the conservation of energy.	2
• Draw a correct direction for the induced current. OR • Provide some jusitfication by referring to the Lenz Law OR the conservation of energy.	1

Question 27 (4 marks)

Q27

Criteria	**Marks**
• Applies Newton's Third law to the ampere definition and calculates the force between the two wires	**4**
• Applies Newton's Third law to the ampere definition and shows some correct working when calculating the force between the two wires	**3**
• Applies Newton's Third law to the ampere definition OR • Calculates the force between the two wires	**2**
• Provides some correct information	**1**

Sample answer: In the definition the conductors exert equal and opposite forces on each other according to Newton's Third Law. The force on conductor 1 by conductor 2 (action) is equal in size but opposite in direction to the force on conductor 2 by conductor 1 (reaction). The forces may pull the conductors together or push the conductors apart.

The size of the force is given by:

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

$F = 2 \times 10^{-7} \times (0.375)^2 / (13.5 \times 10^{-3})$

$= 2.08 \times 10^{-6}$ N

$$\times \mathbf{0.65} = \mathbf{1.35 \times 10^{-6} N}$$

Question 28a (1 marks)

Criteria	Mark
• ALL the data correctly plotted.	1

Question 28b (5 marks)

Criteria	Mark
• Describe a DC motor. • State Lenz's/Faraday's/Law • Apply Lenz's/Faraday's/Law to the rotor to explain the back emf and the current decrease as the angular speed increases. AND • Recall that electrical power is given by P=VIt • Describe energy as being transferred from the rotor to the load. • Apply conservation of energy to explain that energy is needed to keep the rotor rotating.	5
• Describe a DC motor. • State Lenz's/Faraday's/Law • Apply Lenz's/Faraday's/Law to the rotor to explain the back emf and the current decrease as the angular speed increases. AND • Describe energy as being transferred from the rotor to the load. • Apply conservation of energy to explain that energy is needed to keep the rotor rotating.	4
• State Lenz's/Faraday's/Law • Apply Lenz's/Faraday's/Law to the rotor to explain the back emf and the current decrease as the angular speed increases. OR • Describe energy as being transferred from the rotor to the load. • Apply conservation of energy to explain that energy is needed to keep the rotor rotating.	2-3
• Provide relevant knowledge about DC motor.	1

Question 28c (2 marks)

Criteria	Mark
• Curve of best fit in the data. AND • Extrapolation coherent with previous question.	2

• Curve of best fit in the data. OR • Extrapolation coherent with previous question.	1

Question 29 (8 marks)

Criteria	**Marks**
Shows a comprehensive understanding of the implications of Maxwell's theory (typically four key points) Relates the results of Hertz's experiments (or other appropriate experiments) to Maxwell's theory (typically two investigations outlined and related to Maxwell's theory)	**7-8**
Provides details of Maxwell's theory Describes Hertz's experiments	**5-6**
Provides details of Maxwell's theory OR Describes Hertz's experiments	**3-4**
Provides some relevant information.	**1-2**

Sample answer: In 1864 Maxwell put forward his electromagnetic theory of light propagation, stating that electricity, magnetism, and light could all be explained using the same theory. He realised the significance of experiments done by Faraday converting electrical energy to magnetic energy. He proposed that light was propagated by alternating electric and magnetic fields, which he believed would vibrate perpendicular to one another in the form of an electromagnetic transverse wave. He described the mutual induction of time and space changing perpendicular electric and magnetic fields. Maxwell's equation postulated that the speed of all electromagnetic waves was 1/✓(μ0 e0) and found the value to be very close to the experimental speed of light, providing evidence for his theory of the nature of light. He went on to predict that there would be a continuous frequency range of electromagnetic radiation which extended beyond the visible spectrum at both ends.
Soon after Maxwell died, Hertz performed a series of experiments in which he produced electromagnetic waves of various frequencies, including radio waves which are beyond the visible spectrum. A transmitter produced an oscillating spark which induced sparks across the gap of a nearby induction coil. By an interference experiment, Hertz found the speed of the waves between the transmitter and the receiver was the same as the accepted speed for light,

and the waves exhibited the properties of light, including polarisation and reflection, providing evidence for Maxwell's work.

Question 30 (4 marks)

Criteria	**Marks**
Relates intensity of transmitted light to angular position of right lens and Malus' law AND Clearly articulates the difference in transmission between the lenses	**4**
Relates intensity of transmitted light to position of right lens and Malus' law States left lens not polarised	**3**
Relates intensity of transmitted light to angular position of lens	**2**
Describes some relevant information regarding polarisation.	**1**

Sample answer: As the light source is polarised, the light intensity as it passes through a second polariser will vary with the angle between the polarisers as described by Malus' Law $I = I_{max} \cos^2\theta$.

Since the intensity of the polarised light varies from high (top position) to low (bottom position) with the angle of the right lens, it must be polarised. There is a lack of change in intensity through the left lens at the same angles indicating that it must not be a polarised lens.

Question 31 (4 marks)

Criteria	**Marks**
Evidence provided that the graph is consistent with Wien's law including detail of the expected relationship between temperature and peak wavelength. AND	**4**

At least one point provided as example if relationship is also described or three points if relationship is not described. AND A clear link to the position of sample points on the graph.	
Evidence provided that the graph is consistent with Wien's law including detail of the expected relationship between temperature and peak wavelength. AND At least one point provided as example if relationship is also described or three points if relationship is not described.	**3**
Evidence provided that the graph is consistent with Wien's law AND At least one point provided as example	**2**
Some relevant information or annotation on graph.	**1**

The graph shows the relationship between temperature and the peak wavelength emitted by a standard blackbody. This is describe by Wien's law $\lambda max = b/T$ where $b = 0.002898$. Wien's law indicates there is an inversely proportional relationship between T and λmax and this is seen in the graph. As T increases, λmax approaches zero and as T approaches zero, λmax increases to infinity.

Taking a sample point from the graph of $(1000, 3x10^{-6})$, this would give a value for the constant in Wien's equation of $b = 0.003$ which is consistent with the accepted value.

Note: Suggest taking at least three points and finding average value of b.

Question 32 (5 marks)

a)

Criteria	**Marks**
Compares classical theory of p=mv with relativistic observation. AND Describes change in mass of object as opposed to constant mass in classical theory AND Links to reason for graph not being a straight line	**3**
Two of above	**2**
One of above	**1**

Sample answer: Classical theory states that momentum is directly proportional to velocity by p = mv. However, this is not the case for high speeds approaching c as shown in the graph. The gradient of the graph increases since the mass of the object increases at high speeds. The

equation that describes the relationship shown in the graph is $p = \frac{m_o v}{\sqrt{1-\frac{v^2}{c^2}}}$ which leads to p approaching infinity as v approaches c.

b)

Criteria	**Marks**
Correct choice of formula AND Correct substitution of values including mass from data sheet.	**2**
One of above	**1**

$p = \frac{m_o v}{\sqrt{1-\frac{v^2}{c^2}}} = 6.69 \text{ x} 10^{-19} \text{ kg ms}^{-1}$

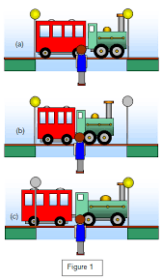
Note: many student left units off. While there were not marks awarded for the units here, it is always good practice to include them.

Question 33 (9 marks)

a.

Criteria	**Marks**
Diagram of thought experiment that shows why length contraction is predicted AND Description of the experiment that shows why the observer in the moving frame of reference will measure contracted length.	**3**
Diagram showing length contraction observed in a moving frame of reference AND Description of length contraction	**2**
Diagram showing length contraction observed in a moving frame of reference OR Description of length contraction	**1**

There are a few appropriate ones. You could use the time dilation experiment (source, mirror, detector) and extend it to the observed distances covered in each frame of reference.



Or something like this one which relates to the relativity of simultaneity. Two lights on a bridge shine when the front and end of a train pass them. The person on the platform sees both lights go on at the same time, so the train is the length of the bridge. The person on the train sees the front light come on before the back light, suggesting they are longer than the bridge. The observer moving relative to the train therefore measures a shorter distance for the train.

b.

Criteria	Marks
Correct formula AND Correct selection of lv and lo AND Correct substitution	**3**
Two of above	**2**
One of above	**1**

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

$$l_v = 10\,000\sqrt{1 - \frac{(0.98c)^2}{c^2}}$$

$$l_v = 1990m$$

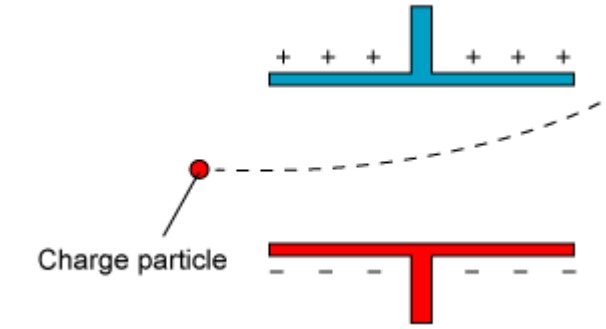
c.

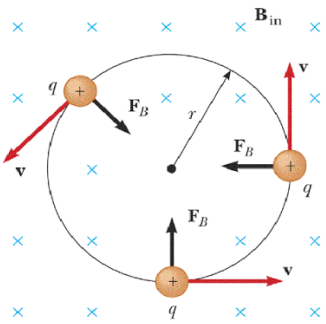
Criteria	Marks
Description of experimental observations regarding muons AND Clear reference to correct frame of motion AND Correct link to length contraction	**3**
Two of above	**2**
One of above	**1**

Muons have a short half-life and it was expected that few would be observed at Earth's surface due to the time it takes to travel the 10km journey (as measured by an observer on Earth) at 0.98c. However, many more muons were observed than expected by classical physics. This provides validation for length contraction since the muons are moving relative to the distance measured by the observer, they travel the contracted length. This means they cover the journey in a shorter time and therefore experience less decay, so more are observed.

Question 34 (4 marks)

Criteria	Marks
Relevant diagrams that show effect of fields on motion of particle x 2 AND Clear comparison of resulting motion of particle.	**4**
Draw the normal force and the static friction force with the correct directions in both diagrams. Identify the contribution of the normal force and the static friction force to the centripetal force.	**3**
Draw the normal force with the correct direction in both diagrams. Identify the contribution of the normal force to the centripetal force.	**2**
Draw the friction force parallel to the road and relate the friction force to the centripetal force.	**1**





Many identified that the resulting trajectories would be parabolic (electric) and circular (magnetic). Better answers linked force (constant magnitude in both, but same direction (electric) vs always orthogonal (magnetic)) on the velocity (speed and direction) of the particle.

Question 35 (7 marks)

a.

Criteria	**Marks**
Correct formula AND Conversion into consistent units (eV or J) AND Correct substitution.	**3**
Two of above	**2**
One of above	**1**

Sample answer

$f = \frac{v}{\lambda}$ = 1.667 x 10^{15} Hz

$$Ek_{max} = hf - \emptyset$$

$$Ek_{max} = 6.626 \times 10^{-34} \times 1.667 \times 10^{15} - 5.01 \times 1.602 \times 10^{-19}$$

$$Ek_{max} = 3.01 \times 10^{-19} J$$

b.

Criteria	**Marks**
Detailed description of interaction of radiation with matter AND Clear links to implications for photoelectric effect explanations.	**3 - 4**
Detailed description of interaction of radiation with matter OR Clear links to implications for photoelectric effect explanations.	**1-2**

Sample answer
In the photon model of light, radiation exists as discrete particles with energies dependent on their frequency by E = hf. When these photons interact with matter, they either deliver all of their energy or none of their energy to electrons. When a single photon hit the surface of a metal, it can give all of its energy to a single electron instantaneously. If the frequency of light is greater than a threshold frequency, such that the energy of the photon is greater than the work function of the material, the electron will be emitted from the surface of the metal. This is the photoelectric effect. If the energy of the photon is greater than the work function, the difference in the energy will result in the electrons having kinetic energy as they leave the surface.