2021
Higher School Certificate
Trial Examination

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided
- For questions in Section II, show all relevant working in questions involving calculations
- Write your student number and/or name at the top of every page

Total marks – 100

Section I (Pages 2–13)
20 marks
- Attempt Questions 1–20
- Allow about 35 minutes for this part

Section II (Pages 14–31)
80 marks
- Attempt Questions 21–35
- Allow about 2 hours and 25 minutes for this section

This paper MUST NOT be removed from the examination room

STUDENT NUMBER/NAME:.....

STUDENT NUMBER/NAME.....

Section I
20 marks

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

Select the alternative A, B, C or D that best answers the question and indicate your choice with a cross (X) in the appropriate space on the grid below.

	A	B	C	D
1				
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	A	B	C	D
11				
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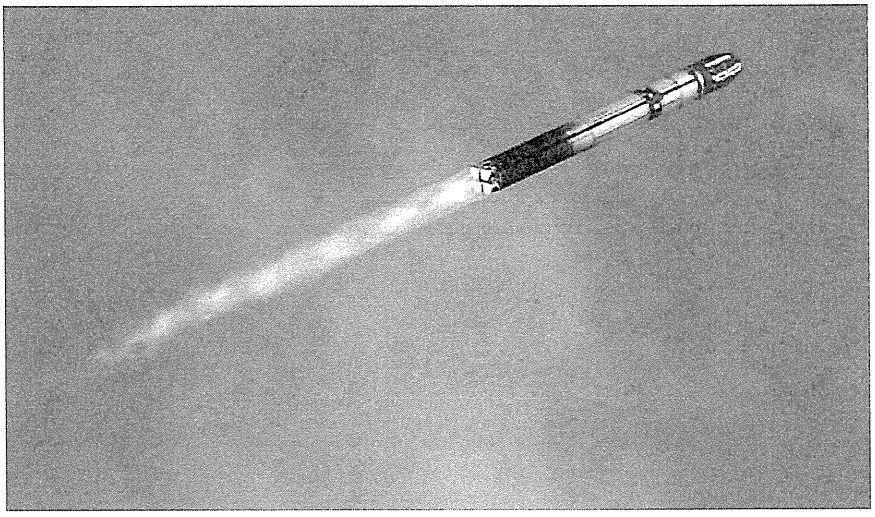
17				
18				
19				
20				

STUDENT NUMBER/NAME.....

1 A photograph is taken of a missile moving at 1800 m s^{-1}. The bottom edge of the image is horizontal.



What is the horizontal component of its velocity at the instant shown?

A. About 763 m s^{-1}

B. About 900 m s^{-1}

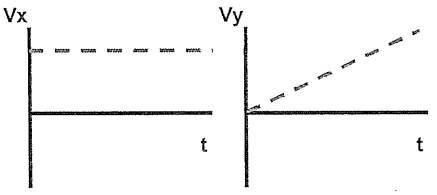
C. About 1110 m s^{-1}

D. About 1630 m s^{-1}

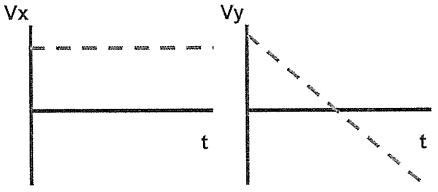
2 A cannon ball is fired into the air towards a distant castle.

Which graphs below correctly show the horizontal and vertical components of the cannon ball's velocity?

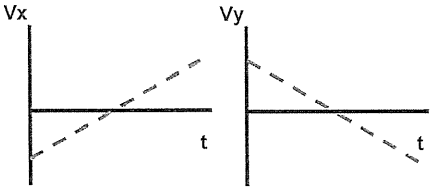
A.



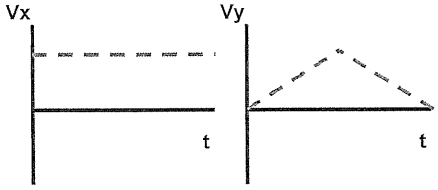
B.



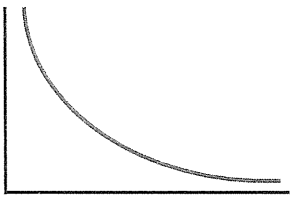
C.

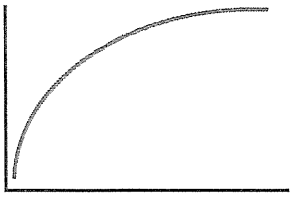


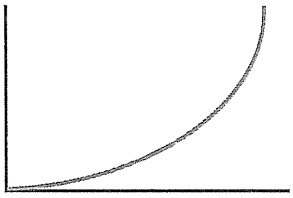
D.

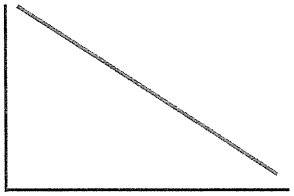


3 Which graph best shows the relationship between gravitational field strength (y-axis) and distance from the centre of a planet (x-axis)?

A. 

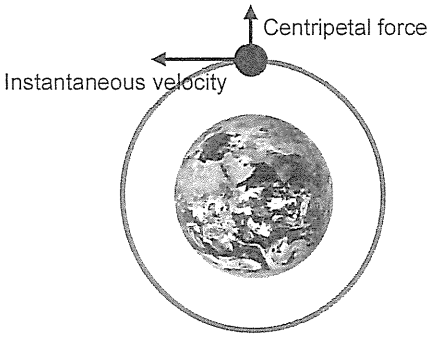
B. 

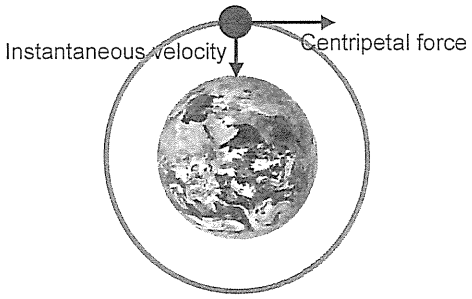
C. 

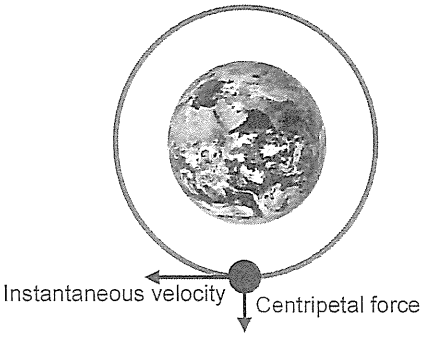
D. 

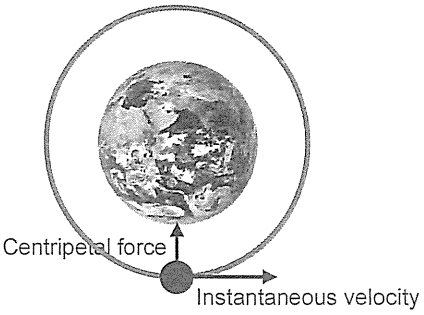
4 Which shows the relationship between the centripetal force acting on an orbiting satellite and its instantaneous velocity?

The satellite is orbiting in an anticlockwise direction.

A. 

B. 

C. 

D. 

5 Which statement about the total energy of an orbiting satellite is correct?

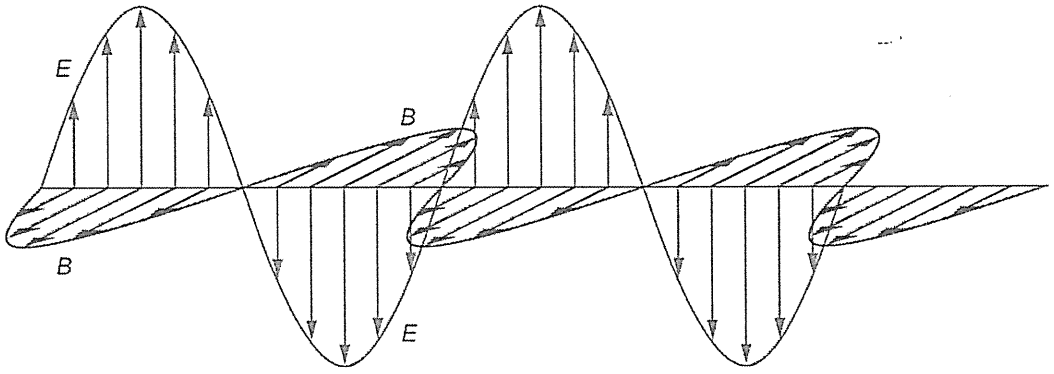
A. The total energy is equal to the sum of its gravitational potential energy and its orbital kinetic energy.

B. The total energy is equal to the difference between its gravitational potential energy and its orbital kinetic energy.

C. The total energy is twice its gravitational potential energy.

D. The total energy is equal to half its orbital kinetic energy.

6 The diagram below of electric and magnetic fields is part of a mathematical theory proposed by a scientist in 1865.



Which statement about the diagram is correct?

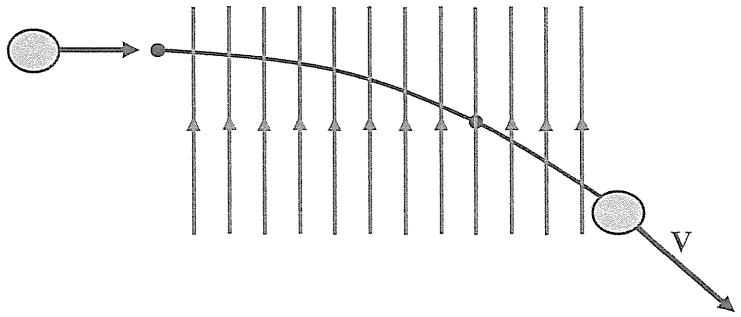
A. The diagram showed transverse vibrations of the aether caused by electric and magnetic fields.

B. The diagram showed electric and magnetic fields moving through each other in opposite directions.

C. The diagram showed electric and magnetic fields produced by oscillating charges which are self-propagating.

D. The diagram represented Einstein's theory of electromagnetic waves travelling at the speed of light.

7 Consider the path of the charged particle through the horizontal field shown in the diagram below.



Which statement about the horizontal field and the charge of the particle is correct?

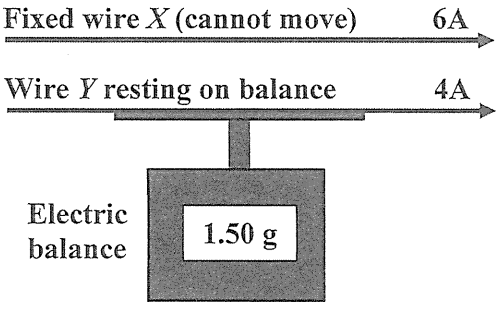
A. The field is an electric field and the charge is positive.

B. The field is an electric field and the charge is negative.

C. The field is a magnetic field and the charge is positive.

D. The field is a magnetic field and the charge is negative.

8 A student did an experiment using the apparatus shown. Both wires are part of separate electric circuits and the currents in each are shown.



Which statement about this situation is correct?

A. If the current in the top conductor is increased, the reading on the balance will increase.

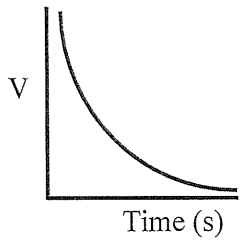
B. If the current in the bottom conductor is increased, the reading on the balance will increase.

C. If the current in the top conductor is decreased, the reading on the balance will decrease.

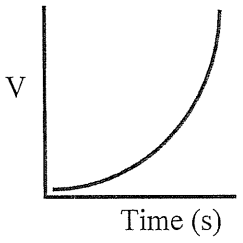
D. If the current in the bottom conductor is decreased, the reading on the balance will increase.

9 Which graph correctly shows the potential difference induced across a wire which cuts a magnetic field at a constant rate?

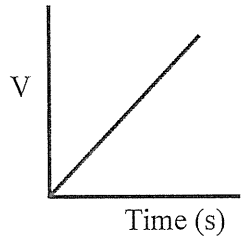
A.



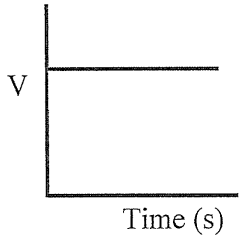
B.



C.



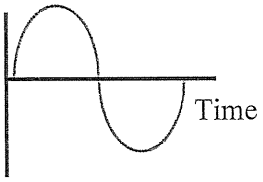
D.



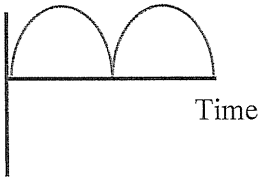
10 A coil in a simple DC motor rotates through 360° within a magnetic field. Initially the plane of the coil is parallel to the magnetic field.

Which graph best shows how the magnetic flux through the coil varies during one rotation?

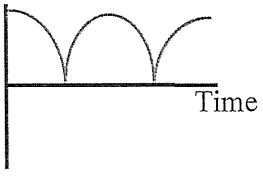
A. Flux



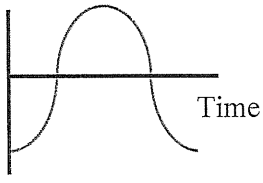
B. Flux



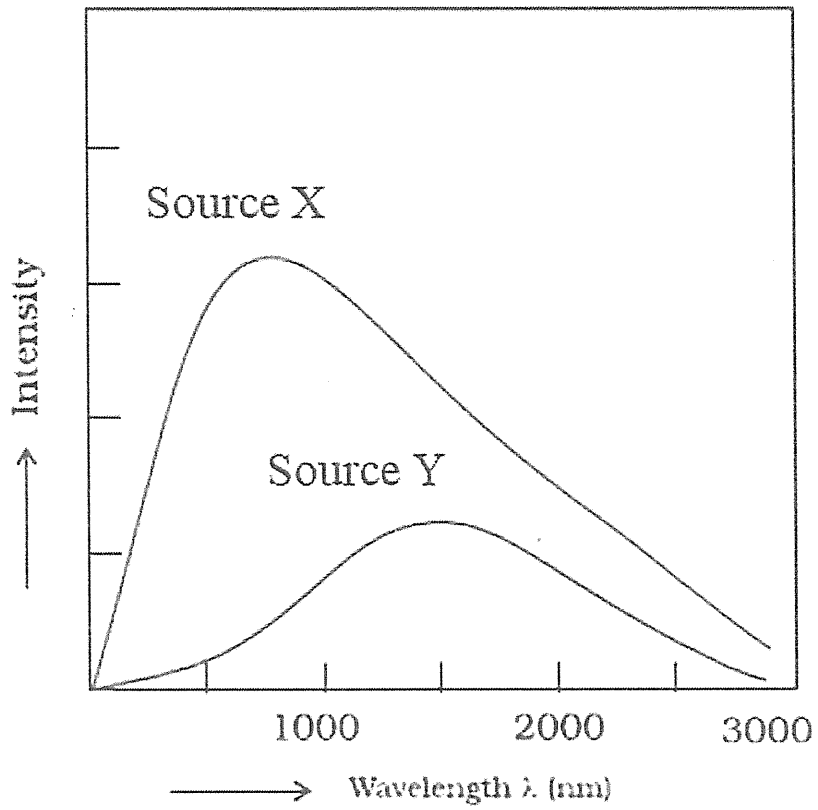
C. Flux



D. Flux



11 The diagram shows the intensity versus wavelength graphs for spectra from two light sources *X* and *Y*.



Which statement explains the difference between the graphs?

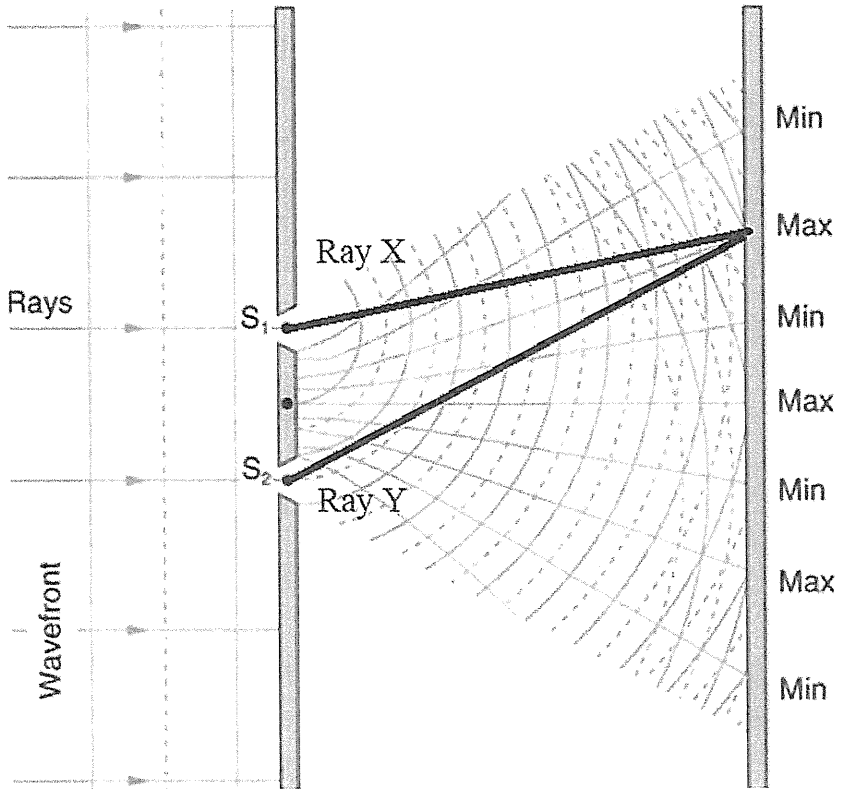
A. Source *Y* is "cooler" because the intensity in the low wavelength region of its spectrum is greater.

B. Source *Y* is "warmer" because the intensity in the low frequency region of its spectrum is greater.

C. Source *X* is "warmer" because the intensity in the blue region of its spectrum is greatest.

D. Source *X* is "cooler" because the intensity in the high frequency region of its spectrum is greater.

12 A light source wavelength λ, shines on two slits S_1 and S_2 separated by a distance *d*. Two light rays, from slit S_1 and slit S_2, are shown in the diagram.



According to the information in the diagram, what is the path difference between rays X and Y?

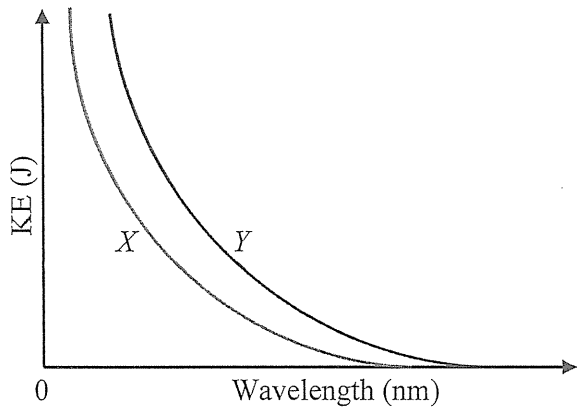
A. 0.5 λ

B. 1.0 λ

C. 1.5 λ

D. 2.0 λ

13 Light of varying wavelengths shines on two different metals *X* and *Y*. The graphs show how the kinetic energy (KE) of the electrons emitted from *X* and *Y* varies as the wavelength of the incident light is changed.



Which statement about the properties of emitters *X* and *Y* is correct?

A. For the same incident light, electrons from emitter *X* are emitted with more kinetic energy than from emitter *Y*.

B. Emitter *Y* has a lower work function than emitter *X*.

C. The threshold frequency of emitter *X* is less than that of emitter *Y*.

D. Electrons in emitter *Y* are held by stronger forces than those in emitter *X*.

14 Who was the first scientist to propose a principle of relativity?

A. Galileo

B. Newton

C. Maxwell

D. Einstein

15 A microwave message is sent from Earth to a spaceship which is travelling directly towards Earth at a speed of 0.4 c.

At what speed is the message received by the spaceship?

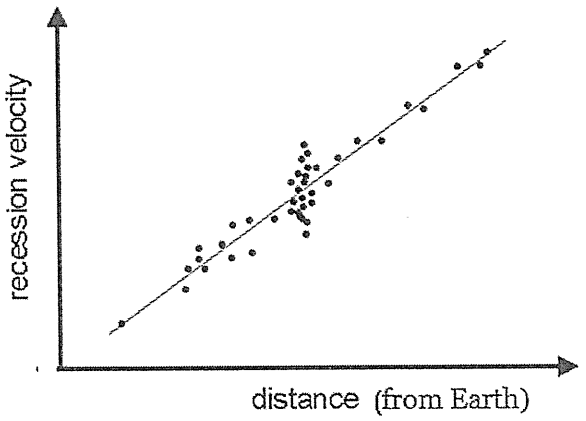
A. 0.4 c

B. 0.1 c

C. 1.0 c

D. 1.4 c

16 The graph shows the recession velocities of galaxies compared to their distance from Earth.



What conclusion have astronomers made from this graph?

A. The speed at which galaxies move away from Earth is inversely proportional to their distance from Earth.

B. The speed at which galaxies move away from Earth is directly proportional to their distance from Earth.

C. Galaxies further from Earth move faster because they were propelled with higher speeds in the Big Bang event.

D. Galaxies closer to Earth move slower because they are in a more densely populated region of space and gravitational forces are therefore stronger.

17 The equations below show three reactions in the most common proton-proton chain producing energy in the Sun.

Reaction A: $2{}_1^1H + 2{}_1^1H \rightarrow 2{}_1^2H + 2{}_1^0\overline{e} \mp 2\nu_e$

Reaction B: $2{}_1^2H + 2{}_1^1H \rightarrow 2{}_2^3He + \gamma$

Reaction C: $2{}_2^3He + 2{}_2^3He \rightarrow {}_2^4He + 2{}_1^1H$

According to this information, what is a possible net proton-proton reaction?

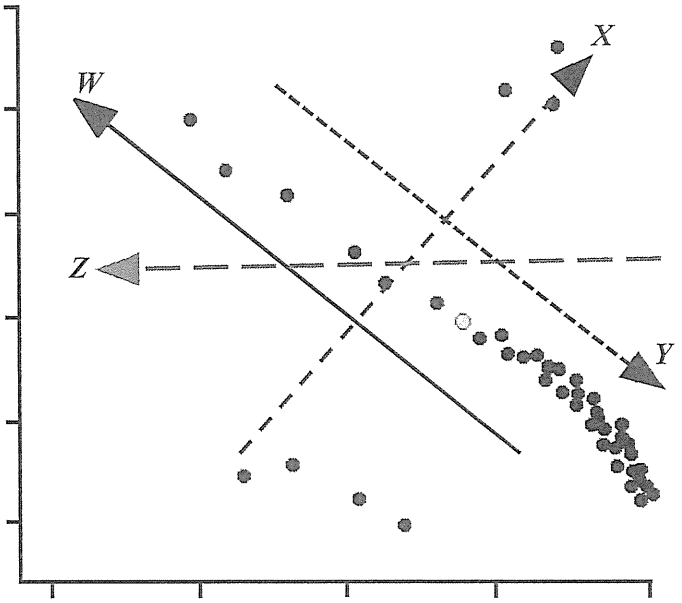
A. $4{}_1^1H \longrightarrow {}_2^4He + 2{}_1^0\overline{e} + \gamma + 2\nu_e$

B. ${}_1^1H + 2{}_1^2H \longrightarrow {}_2^4He + 2{}_1^0\overline{e} + \gamma$

C. $4{}_1^1H \longrightarrow {}_2^4He + 2{}_1^0\overline{e}$

D. $2{}_1^1H + {}_2^3He \longrightarrow 2{}_1^2He + 2{}_1^0\overline{e} + \gamma$

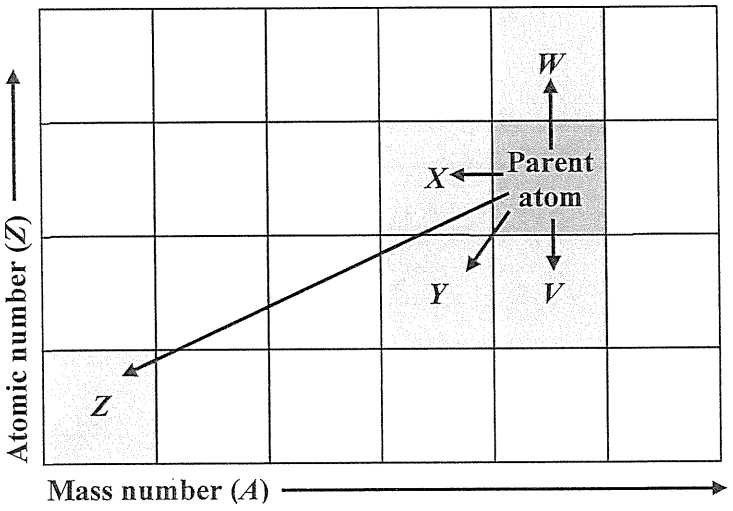
18 The diagram (below) is a simple Hertzsprung-Russell diagram for the nearby stars. On it are drawn several trend lines, labelled *W*, *X*, *Y* and *Z*. Note that the usual labels on the axes have been omitted.



Which choice correctly identifies these trends?

	Arrow *W*	Arrow *X*	Arrow *Y*	Arrow *Z*
A.	Size	Mass	Temperature	Life span
B.	Temperature	Mass	Life span	Size
C.	Mass	Temperature	Life span	Size
D.	Mass	Size	Life span	Temperature

19 The diagram below shows the possible nuclear decay pathways for a radioactive isotope labelled the parent atom.



Which choice correctly identifies the decay pathways for this parent atom?

	Beta decay	Positron decay	Alpha decay
A.	V	W	Y
B.	W	V	Z
C.	W	Z	V
D.	Z	Y	W

20 Which statement about electrons is correct?

A. Electrons are not fundamental particles.

B. Electrons are composed of 2 different quarks.

C. Electrons are one type of the 6 different types of leptons.

D. Electrons are composed of 2 identical leptons.

STUDENT NUMBER/NAME.....

Section II

80 marks
Attempt Questions 21–35
Allow about 2 hours and 25 minutes for this part

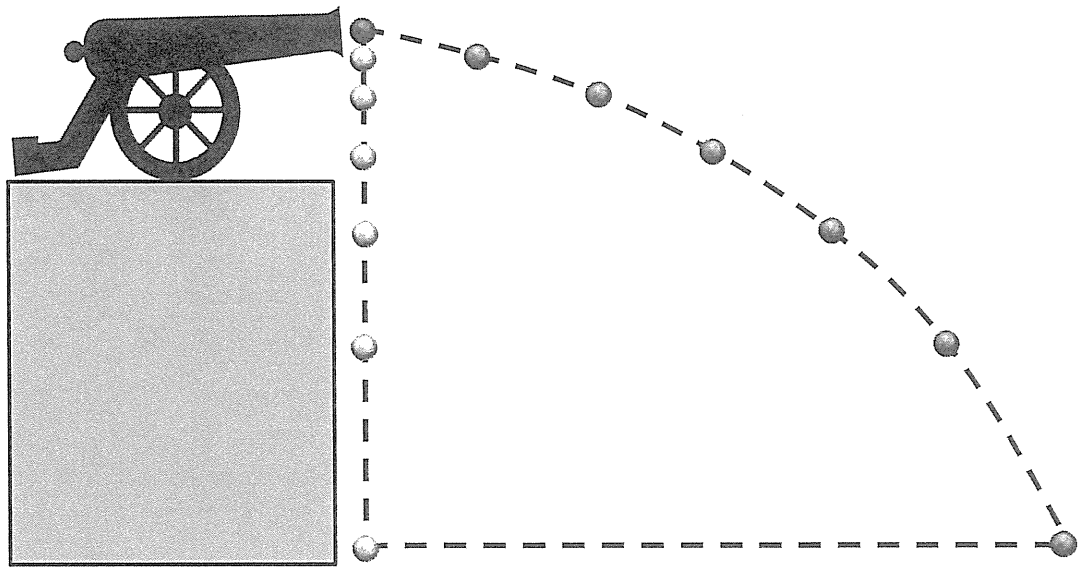
Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculations.

Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Question 21 (5 marks)

At the instant a cannon fires a ball horizontally, another is dropped from the same height. The stroboscopic images of the motion of two balls are shown in the diagram. The camera captured one frame every 0.1 s.



Question 21 continues on the next page

Question 21 (continued) **Marks**

(a) Explain how this diagram illustrates characteristics of projectile motion proposed by Galileo. **2**

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(b) Use the diagram to determine the launch velocity of the projectile. **3**

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End of Question 21

STUDENT NUMBER/NAME.....

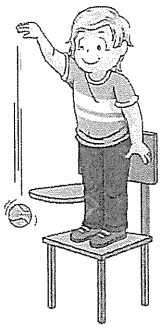
Question 22 (5 marks) **Marks**

Students did two experiments to determine the acceleration due to gravity. **5**

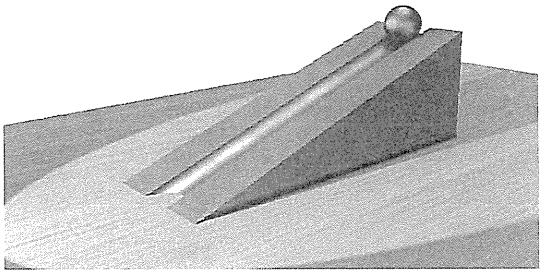
Experiment 1:
5 balls of different masses; dropped from 5 different heights above the ground.
Time taken for each ball to reach the ground recorded.
Repeated 5 times for each ball. Times averaged in the results.

Experiment 2:
Same 5 balls of different weight; rolled down a 5 m long grooved ramp.
Balls stated from 5 different positions on the ramp.
Time taken for each ball to reach the ground recorded.
Repeated 5 times for each ball. Times averaged in the results.

Experiment 1



Experiment 2



Compare the validity, reliability and accuracy of the experiments on the basis of the information provided.

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STUDENT NUMBER/NAME.....

Question 23 (5 marks) **Marks**

A rocket is in orbit, distance R from the centre of the Earth. At this height it has gravitational potential energy (U) equal to –4E Joules. The rocket is then boosted to an orbit where its gravitational energy is –E.

(a) Complete the table to show the missing values. **2**

	Gravitational potential energy (J)	*Orbital kinetic energy (J)*	*Total energy (J)*
Initial position	–4E		
Final position	–E		

(b) Explain how the gravitational potential energy of the rocket seems to decrease from –4E to –E even though it is boosted to a higher orbit. **1**

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(c) Justify the change in kinetic energy of the rocket by deriving the relationship between velocity of an orbiting object and the radius of its orbit. **2**

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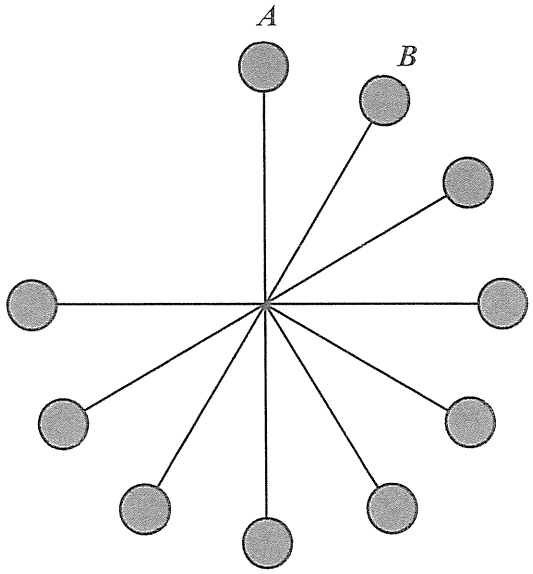
STUDENT NUMBER/NAME.....

Question 24 (6 marks) **Marks**

The diagram shows the motion of a 250 g mass in circular motion on a horizontal plane. Images captured with a stroboscopic camera with a frequency of 12 Hz. The orbital speed of the mass was 3.5 m s^{-1}. Two positions of the mass have been labelled.



(a) What is the radius of the circle of motion? 2

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(b) What is the tension in the string connecting the mass to the centre? 1

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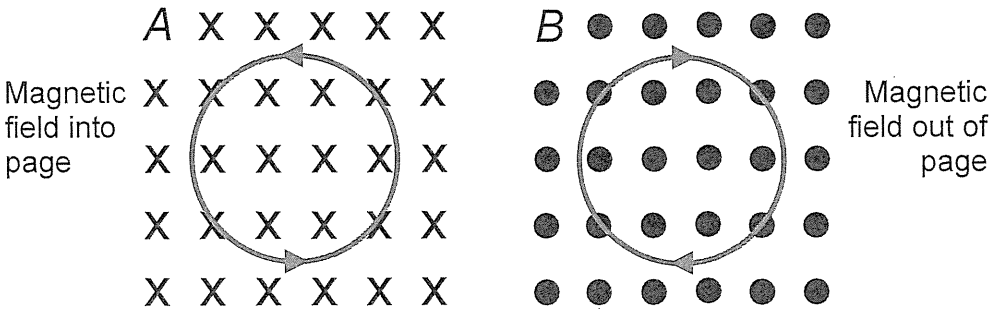
(c) On the diagram above, use a vector analysis to show that the change in velocity of the object moving from position *A* to *B* is directed approximately towards the centre of the circle. 3

STUDENT NUMBER/NAME.....

Question 25 (4 marks) **Marks**

Charged particles *A* and *B* move into a magnetic field and move along different circular paths.



(a) A student observes the diagrams and states that *A* and *B* are both negatively charged. 1

Evaluate this statement.

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(b) Particle *A* is more massive than particle *B*. 3

Explain how it is possible for the radii of their paths in the fields to be identical.

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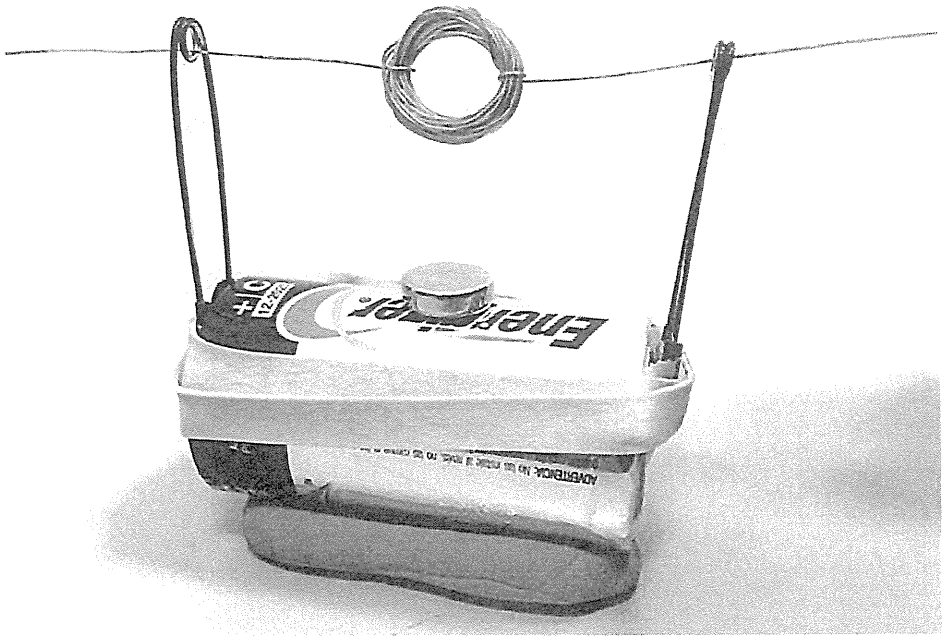
STUDENT NUMBER/NAME.....

Question 26 (4 marks) **Marks**

The diagram shows a simple DC motor made by a student. 4



A student constructed the simple DC motor using insulated wire, a battery and a small strong disc magnet. Safety pins were used to contact the coil to the battery which was held by plasticene. One end of the wire had all the insulation removed where it rested on the safety pin and the other end had the insulation removed on half the circumference of the wire where it rested on the safety pin.

Identify the vital component missing in this motor that is contained in all manufactured DC motors, describe its function and explain why this student motor works without this component.

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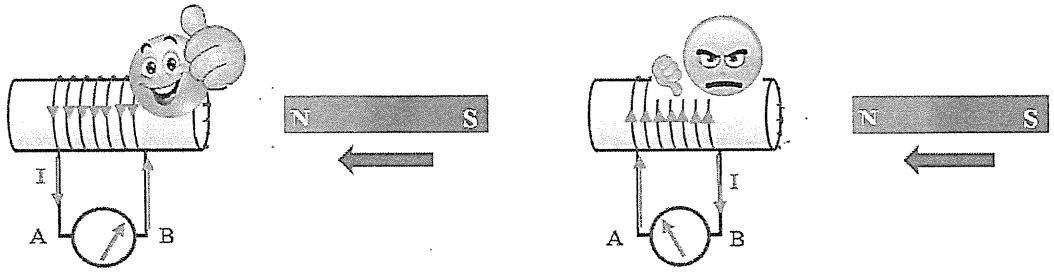
STUDENT NUMBER/NAME.....

Question 27 (4 marks) **Marks**

A teacher uses a law of physics to explain why only the left diagram below depicts a valid experiment when a magnet is moved towards the coil. **4**



Identify one physics law and use it to explain why the diagram on the right is not valid.

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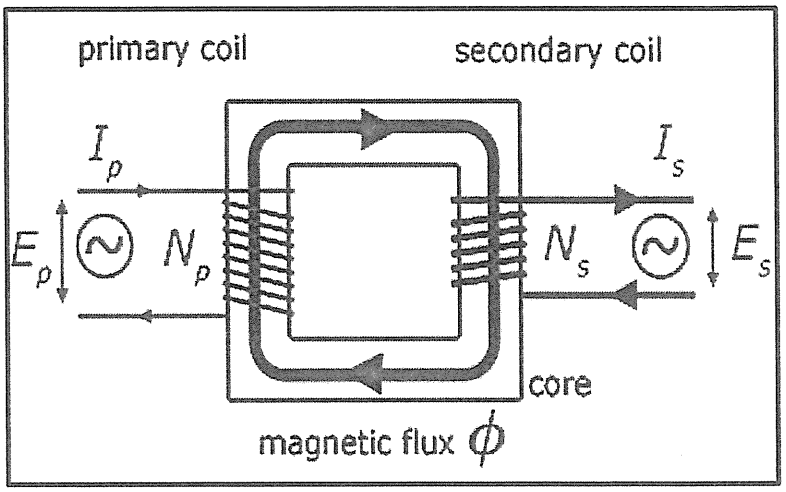
Question 28 (4 marks)

Students did an experiment to study the operation of a transformer.

A circuit contained a transformer which kept the voltage constant at 30 V across the primary coil.

The number of turns in the primary coil was also kept constant at 450 but the number in the secondary coil was changed.



Their results are shown in the table below.

Input voltage (V)	*Turns in primary coil*	*Current in primary circuit (A)*	*Turns in secondary coil*	*Output voltage (V)*
30	450	5	150	9.8
30	450	5	300	19.5
30	450	5	450	29
30	450	5	600	38
30	450	5	750	47
30	450	5	900	55

Question 28 continues on the next page

STUDENT NUMBER/NAME.....

Question 28 (continued) **Marks**

(a) Identify if were the students using a step up or a step-down transformer? Justify your answer. **2**

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(b) Identify TWO reasons why everyday transformers are not 100% efficient. **2**

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End of Question 28

STUDENT NUMBER/NAME.....

Question 29 (8 marks) **Marks**

Outline how the particle model of light as proposed by Newton and the wave model formulated by Huygens explained THREE properties of light. 8

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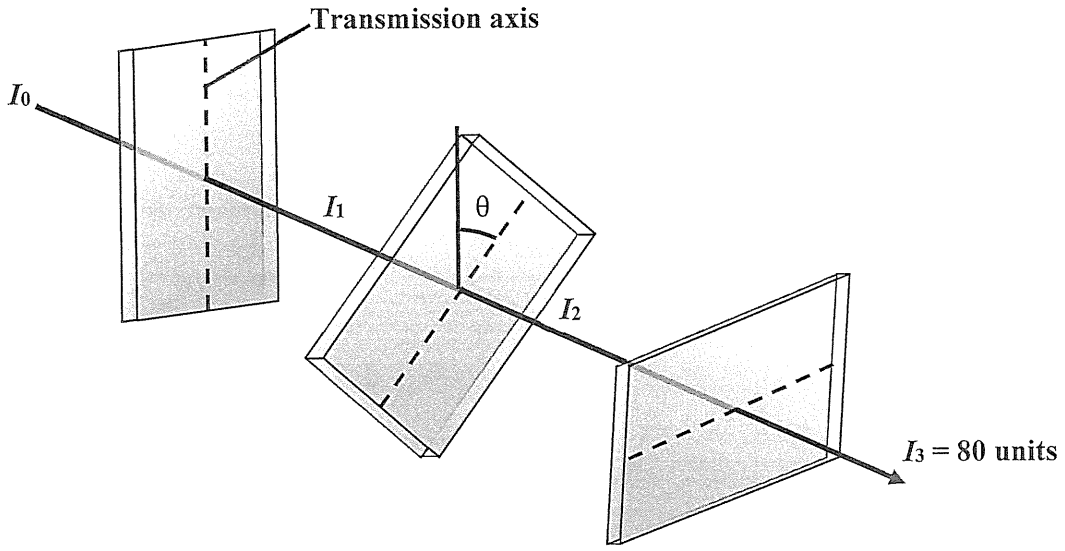
STUDENT NUMBER/NAME.....

Question 30 (4 marks) **Marks**

The diagram shows light I_0 passing through three polarising sheets. The intensity of the light I_3 through the final sheet is 80 units. 4

The transmission axis of the first sheet is vertical and the transmission axis of the end analyser is horizontal. The angle Θ between the planes of polarisation of first and second sheets is 30°.



Determine the intensity of the light incident on the polariser, I_o.

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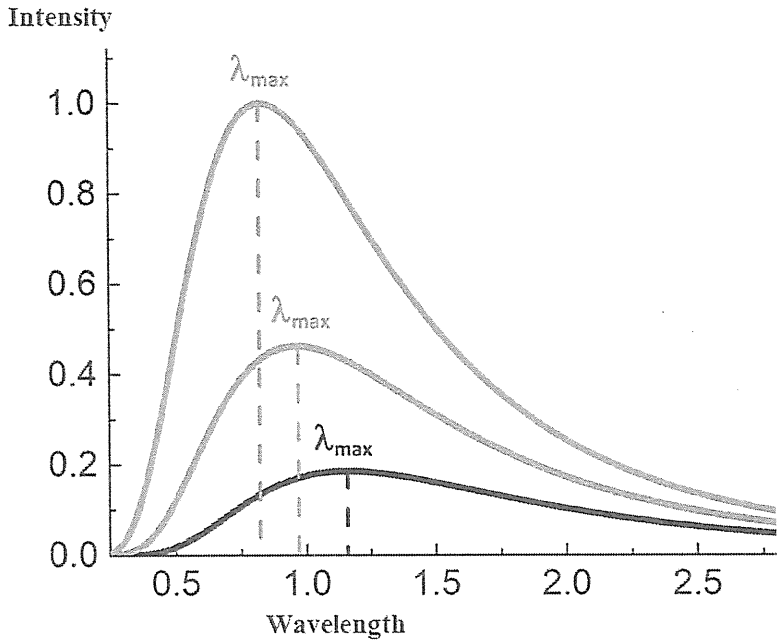
STUDENT NUMBER/NAME.....

Question 31 (5 marks) **Marks**

The graph below shows typical experimental results for the wavelength of the peak intensity of the heat energy radiated by black bodies with different surface temperatures. **5**



Outline how Planck solved the problem presented by the above graphs and the influence of his work 13 years later on Bohr's model of the hydrogen atom.

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Question 32 (6 marks) **Marks**

Outline the concept of stopping voltage in photoelectric experiments and explain its importance in understanding photoemission of electrons from an emitting surface. Support your answer with relevant equations. 6

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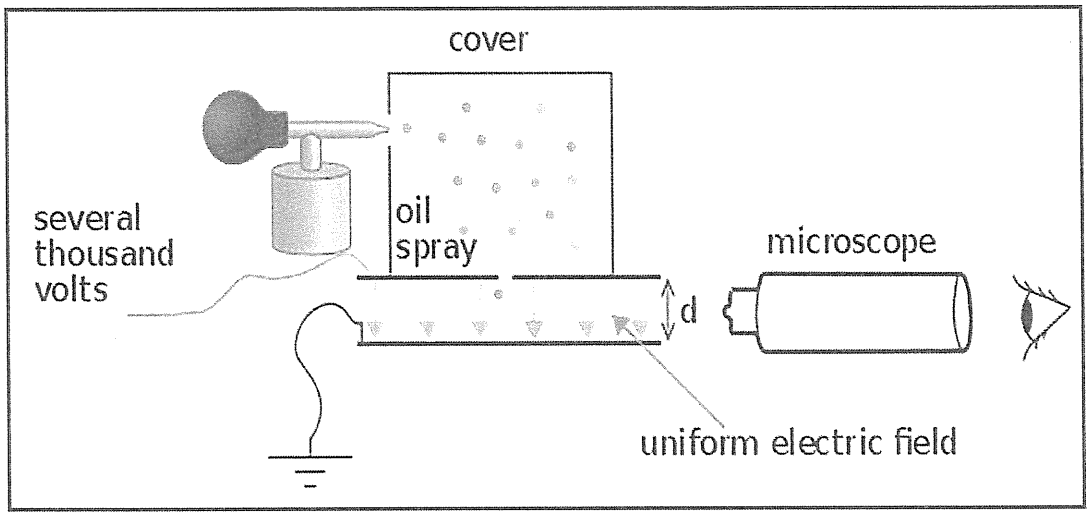
STUDENT NUMBER/NAME.....

Question 33 (8 marks) **Marks**

The diagram shows apparatus similar to that used by Millikan in his experiments with oil drops in 1909. 8



Explain how Millikan used this apparatus and how his interpretation of the results contributed to our understanding of the structure of matter. Support your answer with relevant equations.

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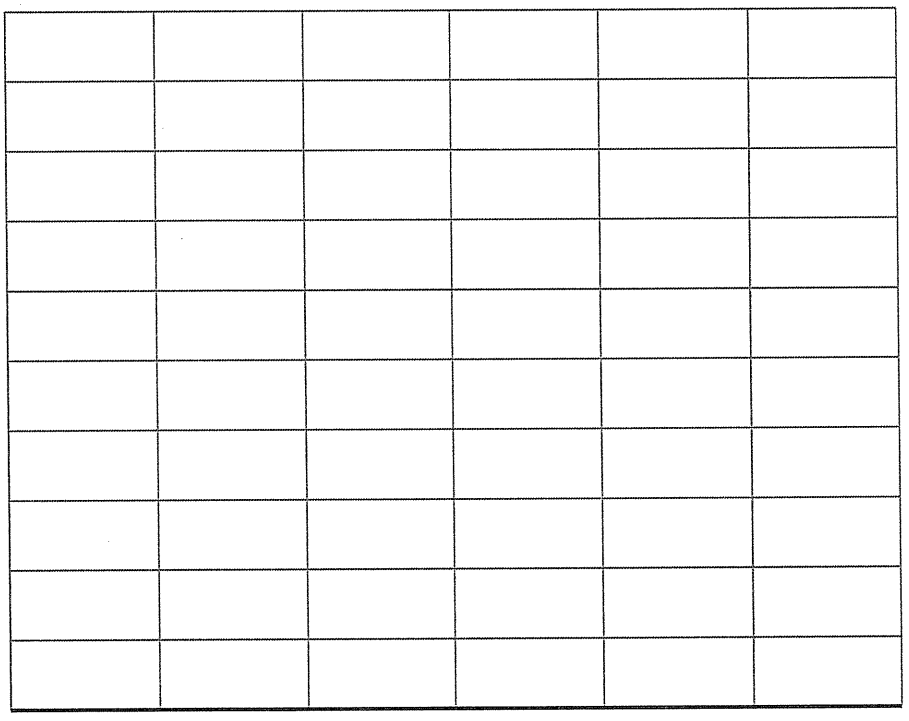
Question 34 (7 marks) **Marks**

A nuclear scientist investigated the properties of radioisotope, *X*. Before starting the experiment, he measured the background radiation and obtained an average measure of 10 counts per minute. He then tested the radioactivity of the radioisotope every minute for 5 minutes. The results are shown in the table.

Time (minutes)	*Total radiation recorded (counts min^{-1})*
0	90
1	54
2	35
3	27
4	22
5	16

(a) Graph the changes in radioactivity of the sample over time on the axes below. **3**



Question 34 continues on the next page

Question 34 (continued) **Marks**

(b) Determine the decay constant for X. **2**

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(c) If the initial mass of the sample was 10 g, estimate its mass after 6 minutes. Justify your answer. **2**

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Question 35 (5 marks)

Outline the nature and role of quarks in the Standard Model of matter. **5**

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End of paper

STUDENT NUMBER/NAME.....

Extra writing space

NSW INDEPENDENT TRIAL EXAMS – 2021
PHYSICS – TRIAL HSC EXAMINATION
MARKING GUIDELINES

Section I

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

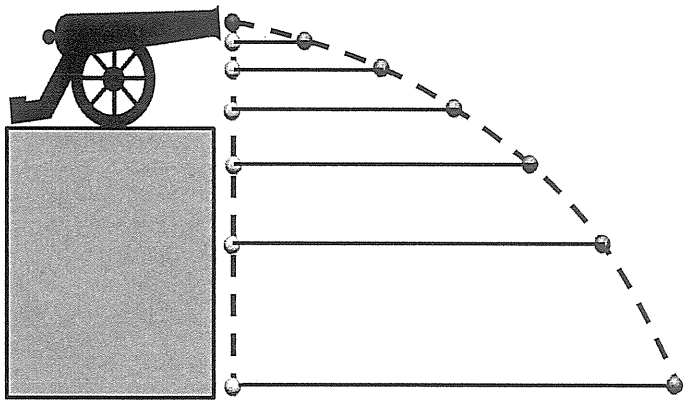
Section II

Q21(a)

Criteria	Marks
• Provides relevant information from diagram to show constant horizontal motion and uniform vertical acceleration for projectile motion	2
• Provides relevant information from diagram to show constant horizontal motion OR • Provides relevant information from diagram to show uniform vertical acceleration for projectile motion	1

Sample answer: Galileo's proposal was that the horizontal velocity of a projectile was constant motion. This is shown by the horizontal distance between the dropped and projected balls in each frame increasing by the same amount.

He also proposed that the vertical component of a projectile's motion was uniformly accelerated with the gravitational acceleration of all falling objects. The photo shows that the balls dropped the same distance every 0.1 s.



Q21(b)

Criteria	Marks
• Correctly calculates the launch velocity	3
• Provides some relevant steps	2
• Provides some relevant information	1

Sample answer:
Time for ball to fall = 0.6 s
From $s = ut + \frac{1}{2}at^2$
We get distance fallen = $\frac{1}{2} \times 9.8 \times 0.6^2 = 1.76$ m
Distance on the diagram = 7.3 cm
Diagram scale: 1 cm = 1.76 / 7.3 m = 0.24 m
Measured the range on diagram = 9.8 cm
Range = 9.8 × 0.24 = 2.36 m
Therefore, horizontal launch velocity = 2.36 / 0.6 = 3.9 m s^{-1}

Q22

Criteria	Marks
• Demonstrates a good understanding of validity, reliability and accuracy and applies each in assessing the experiments	4–5
• Demonstrates a good understanding of TWO terms and applies each in assessing the experiments OR • Provides clear criteria for THREE terms	3
• Provides clear criteria for TWO terms OR • Demonstrates a good understanding of ONE term and applies it in assessing the experiments	2
• Provides clear criteria for ONE term	1

Sample answer: The two experiments would be equally reliable as the average value of multiple readings was used so long as the multiple readings did not differ significantly.

Results from each experiment provide necessary data to calculate the acceleration due to gravity but there are variables that have not been controlled.

Air resistance in Experiment 1 and friction between the ball and edges of groove in Experiment 2 need to be considered. The friction depends on the shape of the groove. The distance fallen in Experiment 1 determines the speed reached which affects air resistance. Both would be valid experiments only if air resistance and friction could be allowed for.

The accuracy of the result depends on the errors in the measurements taken. As no information is provided on equipment used to measure time, distance and angle, no judgement can be made.

Q23(a)

Criteria	Marks
• Provides at least THREE correct values	2
• Provides at least TWO correct value	1

Sample answer:

	Gravitational potential energy (J)	*Orbital kinetic energy (J)*	*Total energy (J)*
In initial position	–4E	2E	–2E
In final position	–E	0.5E	–0.5E

Q23(b)

Criteria	Marks
• Explains the apparent confusion due to negative values as a result of definition	1

Sample answer: The figures are misleading because they are negative values based on the definition of zero gravitational energy for objects at an infinite distance from Earth. A change from –4E to –E is actually an increase of 3E.

Q23(c)

• Criteria	Marks
• Justifies decrease in kinetic energy based on derived orbital velocity formula	2
• Derive formula for orbital velocity	1

Sample answer:

$GMm / r^2 = mv^2 / r$ Therefore, $v = \sqrt{(GM / r)}$

Velocity and kinetic energy decreases with increase in orbit radius.

Q24(a)

Criteria	Marks
• Determines the correct value of the radius	2
• Determines the correct value of the period OR • Determines radius within correct radius	1

Sample answer:
Diagram shows 0.75 rotation = 9 strobe spaces
One rotation = 12 strobe spaces
Therefore, period of rotation = 1.0 s
$v = 2\pi r / t \quad r = 3.5 \times 1 / 2\pi$
Radius of circle = 0.56 m

Q24(b)

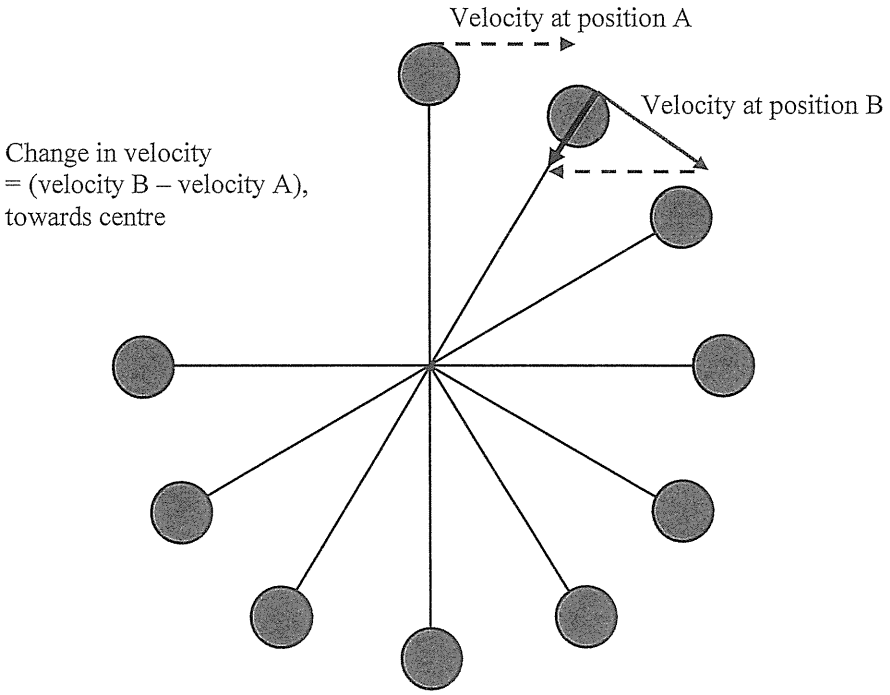
Criteria	Marks
• Calculates tension correctly	1

Sample answer: Tension in string = centripetal force = $mv^2/r = 0.25 \times 3.5^2 \div 0.56 = 5.49$ N acting both ways

Q24(c)

Criteria	Marks
• Provides an appropriate vector subtraction diagram with labels	3
• Provides an appropriate vector subtraction diagram	2
• Draws appropriate vectors for velocity at positions A and B	1

Sample answer:



Q25(a)

Criteria	Marks
• Identifies statement as incorrect with reason	1

Sample answer: Applying the right-hand grip rule to each diagram, we can see that A and B are both positively charged. Statement is incorrect.

Q25(b)

Criteria	Marks
• Identifies THREE possibilities and equation for radius	3
• Identifies TWO possibilities and equation for radius OR • Identifies THREE possibilities	2
• Identifies TWO characteristics that could vary OR • Provides equation for radius	1

Sample answer: Since, $Bqv = mv^2 / r$, $r = mv / Bq$

The radii can be the same with mass A having a larger mass if A's magnetic field or charge is greater than that of B or A has a smaller velocity than B. Some combination of these factors could also be possible.

Q26

Criteria	Marks
• Identifies the name and function of component • Clearly explains how the bared wire ensures rotation	3–4
• Identifies the name and function of component OR • Clearly explains how the bared wire ensures rotation	2
• Identifies the name of component OR • Identifies function of component	1

Sample answer: The missing component is the split ring commutator which ensures that current flow through the coil is always in the same direction relative to the applied magnetic field so that the torque on the coil is also always in the same direction. This is necessary for the coil to rotate 360° rather than reverse direction every half cycle.

In this model, the wire used in the coil is insulated but at one end half the circumference of the wire has been bared where the coil makes contact with the circuit through the paper clips. This prevents current flow for half the rotation which would normally result in the force on the coil being in the wrong direction without a commutator. Inertia will carry it through this half rotation until the bare part of the wire makes contact again and the motor effect force is applied for a half rotation keeping the coil moving.

Q27

Criteria	Marks
• Provides a well-reasoned explanation identifying the physics law and how it would be contravened	4
• Provides relevant statements based on conservation of energy	3
• Provides an explanation based on Faraday's Law of induction and Lenz's Law	2
• States Law of Conservation of Energy	1

Sample answer: The principle is the law of conservation of energy.

When the magnetic north moves closer to the coil, the induced current in the coil must produce a north pole at the right-hand end of the coil to oppose the motion of the magnet towards it as in diagram on the left. The work done by the force is transformed into electrical energy.

If the induced current was in the opposite direction (diagram on right), the induced south pole would accelerate the magnet towards the coil without requiring work to be done. This would contravene the law of conservation of energy.

Q28(a)

Criteria	Marks
• Provides evidence for both types of transformer and third reading anomaly	2
• Provides evidence for both types of transformer	1

Sample answer: For the first two readings the transformer was a step-down transformer because output voltage was lower than input voltage.

For the third reading, with the numbers of turns in the coils equal, it theoretically was not a transformer.

For the last three readings it was a step-up transformer as output voltage was higher than input voltage.

Q28(b)

Criteria	Marks
• Identifies TWO sources of energy loss	2
• Identifies ONE source of energy loss	1

Sample answer: Transformers in operation are not quite 100% efficient as there is some energy lost during any energy transformation. In this case, it is due to flux leakage from the core and eddy currents set up in the core.

Q29

Criteria	Marks
• Shows a comprehensive understanding of how Newton and Huygens applied their models to THREE properties of light	7–8
• Provides details of how Newton and Huygens applied their models to THREE properties of light OR • Shows a good understanding of how Newton and Huygens applied their models to TWO properties of light	5–6
• Provides details of how Newton applied his model to THREE properties of light OR • Provides details of how Huygens applied his model THREE properties of light OR • Provides details of how Newton and Huygens applied their models to TWO properties of light	3–4
• Provides some relevant information	1–2

Sample answer:

Straight line travel

Both the particle model and the wave model agreed that, provided no obstacles were in the way, light would travel in a straight line. According to the particle model, light could travel through a vacuum, but because all known waves at the time needed a medium for travel, the wave model required the hypothesis of the existence of the aether for light as a wave to pass through a vacuum.

Reflection

Newton's model explained reflection by having the light particles simply bouncing back off the reflecting surface. In the wave model, each impact point of an incident ray on the reflecting surface acts as a point source of circular wavelength which spread out from the impact points. The tangent to the circular wavelets forms the reflected wave front with the direction of propagation perpendicular to the wave fronts.

Refraction

Both models stated that refraction was a result of the effect of density change on speed. Newton proposed that the boundary between adjacent media would exert a force on light corpuscles therefore accelerating them to a greater speed and causing refraction. Huygens proposed that light waves would travel slower in a denser medium. (This was experimentally validated as speed of light in water is slower than in air.) This resulted in the wavelets formed from the part of the beam hitting the boundary first to slow down while the rest of the beam continued at the faster speed. As a result, by the time the whole width of the beam has hit the boundary, the direction of travel has changed.

Q30

Criteria	Marks
• Provides correct answer	4
• Provides answer for I_0 using one incorrect angle OR • Calculates I_1 correctly	3
• Provides answer for I_1 using one incorrect angle	2
• Applies one equation correctly	1

Sample answer:
Intensity passing through the second analyser is $I_3 = (\cos 60°)^2 I_2$
Therefore $I_2 = 80 / (\cos 60°)^2 = 320$

Intensity passing through the first analyser = $I_2 = I_1(\cos 30°)^2$
Therefore $I_1 = 320 / (\cos 30°)^2 = 426.6$

Intensity passing through the polariser = $I_1 = 0.5I_o$
Therefore $I_0 = 853$ units

Q31

Criteria	Marks
• Shows a comprehensive understanding of the problem faced by physicists, Planck's solution and its importance in Bohr's model	5
• Shows a clear understanding of Planck's hypothesis and importance in Bohr's model	3–4
• Provides some relevant information	1–2

Sample answer: The experimental graphs such as those shown, did not agree with the graphs predicted by the accepted model for electromagnetic radiation at high frequencies, referred to as the Ultraviolet Catastrophe. Planck assumed that electromagnetic radiation could only be emitted or absorbed in discrete packets whose size was proportional to their frequency. The packets of energy became known as quanta and obeyed the equation $E = hf$. By applying this equation to the mathematical derivation for the predicted graphs, the results agreed in low wavelengths as well as high wavelengths with the experimental observations.

Using Planck's work, Bohr's theory was able to predict the wavelength of the spectral lines produced by energised hydrogen atoms. His theory stated that electrons moved around the hydrogen nucleus in orbits without radiating energy and were able to move between orbits by absorbing or radiating the energy difference as a single quantum of energy, the wavelength given by Planck's equation.

Q32

Criteria	Marks
• Provides clear definition of stopping voltage, how it is used to find kinetic energy and shows a thorough understanding of the importance of Einstein's use of Planck's equation to explain photoelectric experimental results	5–6
• Provides definition of stopping voltage and some details of Einstein's explanation of the photoelectric experimental results	3–4
• Provides some relevant information	1–2

Sample answer: The stopping voltage, V is the voltage magnitude that when applied across the gap between a photoemitter and the collector, stops the electrons from crossing. Its value allows the kinetic energy K of the emitted photoelectrons to be determined, by $K = qV$ where q is the charge on an electron.

Physicists had been unable to explain the experimental results for photoelectric emission such as the minimum frequency and the relationship between frequency of the light and the maximum kinetic energy of the emitted electron. Einstein explained the results by applying Planck's idea of quanta, that is, the energy of light packets is equal to hf. It followed that the kinetic energy of electrons emitted by light of frequency f was equal to the hf minus the energy needed to emit the electron from the metal surface, known as the work function ϕ.

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

This was important in understanding the photoelectric effect and provided evidence for the dual nature of light, both a particle and wave nature.

Q33

Criteria	Marks
• Shows clear understanding of the TWO steps of the experiment with equations and the implications of the results	7–8
• Provides a clear description of the experiment with relevant equations and results	5–6
• Provides a description of the experiment and its results	3–4
• Provides some relevant information	1–2

Sample answer: When Millikan did his experiments, cathode rays had been confirmed as negatively charged particles called electrons and identified as part of atoms. The charge to mass ratio of electrons had been determined by Thomson.

It was known that the droplets in an oil mist could carry electric charge. Millikan introduced oil drops charged by X-rays into an electric field. Initially he adjusted the voltage applied so that the force of gravity balanced the electrostatic force, that is, the net force was zero and the drops were stationary or moving at constant velocity. Therefore, $mg = qE$. Using $E = V/d$, the charge on the drop was given by the equation **$q = mgd / V$.**

The mass of the drops was determined using the known density of the oil and the motion of the drop as it fell under the force of gravity alone.

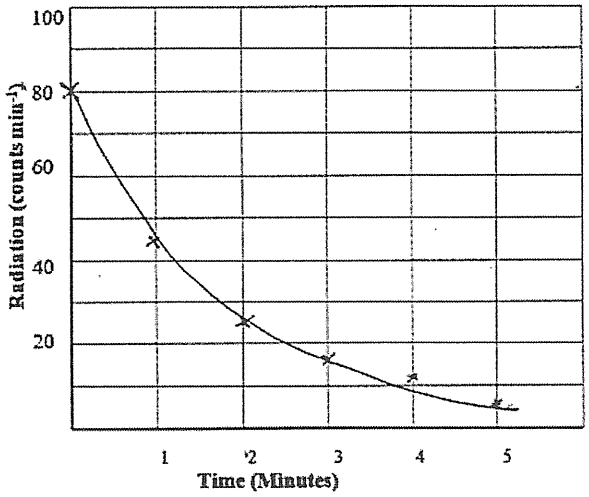
Millikan found through repeated measurements, that the charges on the oil drops were always multiples of the same value, (close to 1.602×10^{-19} C). His results were evidence that the electron charge was the smallest possible charge and that all other charges were simply multiples of this amount.

The charge on the electron was considered to be the **fundamental unit of charge** in all matter.

Q34(a)

Criteria	Marks
• Provides graph with suitable axes labels, corrected radiation values, correctly plotted points, smooth curve	3
• Provides graph with THREE of the following: suitable axes labels, corrected radiation values, correctly plotted points, smooth curve	2
• Provides graph with TWO of the following: suitable axes labels, corrected radiation values, correctly plotted points, smooth curve	1

Sample answer:



Q34(b)

Criteria	Marks
• Determines correct value	2
• Determines constant using incorrect half-life OR • Determined half-life	1

Sample answer: Half-life is 1.3 minutes from graph
Decay constant = ln2 / half-life = 0.6931 / 1.3 = 0.53 min^{-1}

Q34(c)

Criteria	Marks
• Identifies comparative magnitude of mass loss and provides reason	2
• States that cannot be determined OR • States that decrease in mass is very small	1

Sample answer: The mass of the sample would be only slightly less than 10 g and cannot easily be determined from the half-life. Even though about 4 half lives have passed and few of the isotope X atoms remain, each atom of X has been replaced by other atoms. The mass of the radiation emitted would be a very small percentage of the original mass.

Q35

Criteria	Marks
• Shows a comprehensive understanding of the properties and role of quarks using at least ONE example of a baryon	4–5
• Shows a good understanding of the properties and role of quarks	3
• Provides some information about the properties OR role of quarks	1–2

Sample answer: In the Standard Model, there are two types of fundamental particles – the quarks and the leptons. There are six different quarks – *up, down, charm, strange, top* and *bottom*. Quarks carry either positive or negative charges of ⅓ e or ⅔ e. Only up and down quarks exist in matter as we know it. The other four are only detected in very high energy interactions in particle accelerators. Baryons are particles made up of 3 quarks, such the proton which is composed of two *up* quarks (charge +⅔ e) and one *down* quark (charge –⅓ e), giving it a charge overall of +1e. A neutron consists of one *up* quark and two *down* quarks, with an overall charge of zero. Mesons are particles composed of quark and antiquark pairs.

NSW INDEPENDENT TRIAL EXAMS – 2021
PHYSICS – TRIAL HSC EXAMINATION – MARKING GUIDELINES

Question	Marks	Content module		Syllabus Outcomes (PH)	Targeted performance bands
Section I					
1	1	5	Projectile Motion	12-6, 12-12	2-3
2	1	5	Motion in a Gravitational Field	12-5, 12-12	3-4
3	1	5	Motion in a Gravitational Field	12-5, 12-12	2-3
4	1	5	Circular Motion	12-6, 12-12	1-2
5	1	5	Motion in a Gravitational Field	12-5, 12-12	3-4
6	1	7	Electromagnetic Spectrum	12-5, 12-14	3-4
7	1	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-6, 12-13	3-4
8	1	6	The Motor Effect	12-6, 12-13	4-5
9	1	6	Electromagnetic Induction	12-6, 12-13	3-4
10	1	6	Applications of the Motor Effect	12-14	3-4
11	1	7	Electromagnetic Spectrum	12-5, 12-14	4-5
12	1	7	Light: Wave Model	12-6, 12-14	3-4
13	1	7	Light: Quantum Model	12-6, 12-14	5-6
14	1	7	Light and Special Relativity	12-14	2-3
15	1	7	Light and Special Relativity	12-14	2-3
16	1	8	Origins of the Elements	12-5, 12-15	2-3
17	1	8	Properties of the Nucleus	12-6, 12-15	4-5
18	1	8	Origins of the Elements	12-5, 12-15	5-6
19	1	8	Properties of the Nucleus	12-6, 12-15	4-5
20	1	8	Deep inside the Atom	12-15	3-4
Section II					
21(a)	2	5	Projectile Motion	12-7 12-12	2-3
21(b)	3	5	Projectile Motion	12-5, 12-6, 12-12	4-5
22	5	5	Motion in a Gravitational Field	12-3, 12-7, 12-12	3-6
23(a)	2	5	Motion in a Gravitational Field	12-6, 12-12	2-3
23(b)	1	5	Motion in a Gravitational Field	12-7, 12-12	3-4
23(c)	2	5	Motion in a Gravitational Field	12-6, 12-12	3-4
24(a)	2	5	Circular Motion	12-6, 12-12	3-4
24(b)	1	5	Circular Motion	12-6, 12-12	2-3
24(c)	3	5	Circular Motion	12-4, 12-12	4-5
25(a)	1	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-6, 12-13	3-4
25(b)	3	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-6, 12-7, 12-13	4-5
26	4	6	Applications of the Motor Effect	12-7, 12-13	4-5
27	4	6	Electromagnetic Induction	12-7, 12-13	3-5
28(a)	2	6	Electromagnetic Induction	12-6, 12-13	3-4
28(b)	2	6	Electromagnetic Induction	12-13	2-3
29	8	7	Light: Wave Model	12-7, 12-14	3-5
30	4	7	Light: Wave Model	12-6, 12-14	4-6
31	5	8	Quantum Mechanical Nature of the Atom	12-6, 12-7, 12-15	4-5
32	6	7	Light: Wave Model	12-7, 12-14	4-5
33	8	8	Structure of the Atom	12-7, 12-15	3-5
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