2019 HSC Physics Examination

NSW Education Standards Authority

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Exam Overview

Year	2019
Total Marks	100
Section I	20 marks (Questions 1-20, Multiple Choice)
Section II	80 marks (Questions 21-36, Extended Response)

Section I: Multiple Choice

20 marks - Questions 1-20

Allow about 35 minutes for this section

Question 1

1   A projectile is launched by a cannon as shown.

Which arrow represents the velocity of the projectile at its maximum height?

A. ↑

B. ↓

C. ↘

D. →

Figure 1: Q1

Question 2

2   Two stars were observed from Earth. Their spectra are shown with the wavelength in nanometres.

Star *X*:

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|  |      |              |                 |
400          500           600          700
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Star *Y*:

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||        |          |                 |
400          500           600          700
```
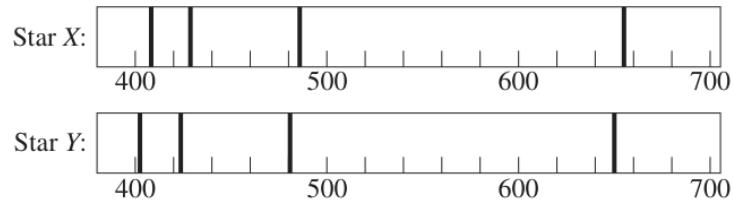
Using these spectra, what can be concluded about the motion of the stars relative to Earth and their chemical compositions?

	Motion relative to Earth	Chemical composition
A.	The same	The same
B.	Different	The same
C.	The same	Different
D.	Different	Different

Figure 2: Q2

3

Question 3

3   Geiger and Marsden carried out an experiment to investigate the structure of the atom.

Which diagram identifies the particles they used and the result that they INITIALLY expected?
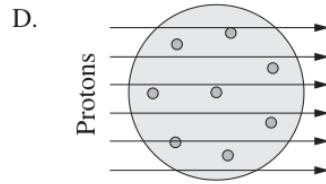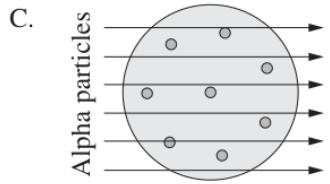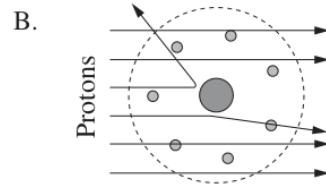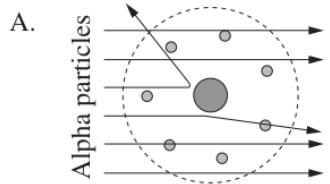
Figure 3: Q3

Question 4

4   Four stars, P, Q, R and S, are labelled on the Hertzsprung–Russell diagram.
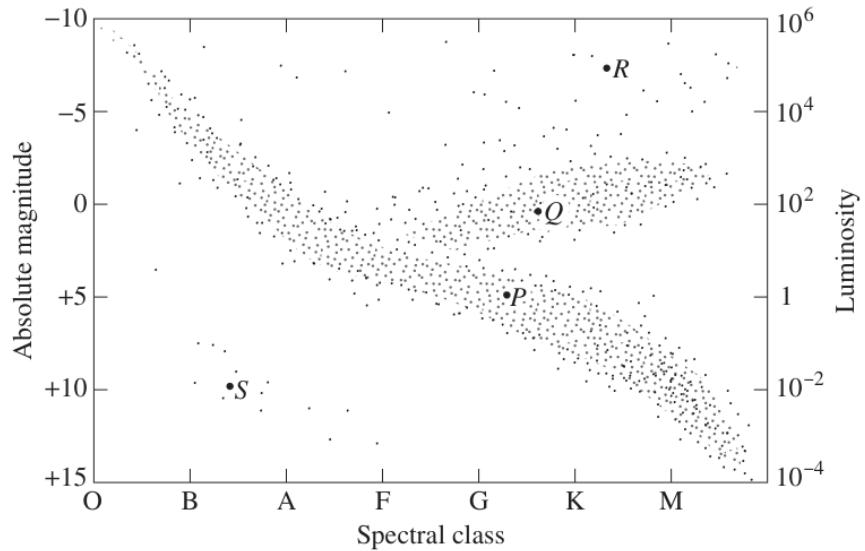
Which statement is correct?

A. S has a greater luminosity than Q.

B. R is a blue star whereas S is a red star.

C. S has a higher surface temperature than R.

D. P is at a more advanced stage of its evolution than R.

Figure 4: Q4

Question 5

5   The diagram shows two coils wound around a solid iron rod. Initially the switch is closed.
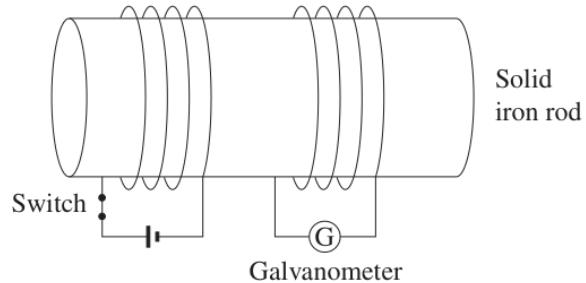
Opening the switch will cause the galvanometer pointer to

A.   remain at a constant reading.

B.   move from a non-zero reading to a zero reading.

C.   move from a zero reading to a non-zero reading, where it remains.

D.   move from a zero reading to a non-zero reading, then back to zero.

Figure 5: Q5

Question 6

6   Which graph correctly shows the relationship between the surface temperature of a black body (T) and the wavelength (λ) at which the maximum intensity of light is emitted?

A.
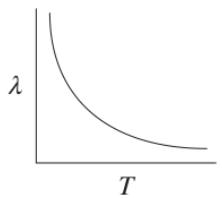
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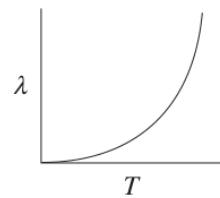
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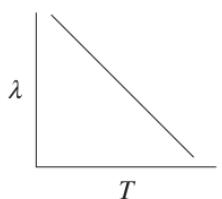
D.
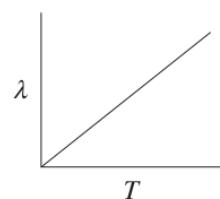
Figure 6: Q6

Question 7

7   A bar magnet is moved away from a stationary coil.

Which diagram correctly shows the direction of the induced current in the coil and the
resulting magnetic polarity of the coil?

A.

N

S   N

B.

N

S   N

C.

S

S   N

D.

S

S   N
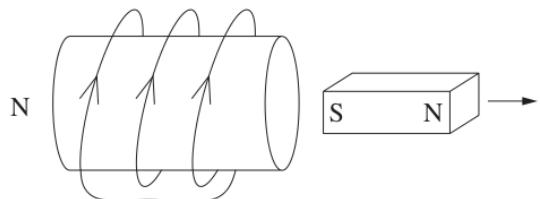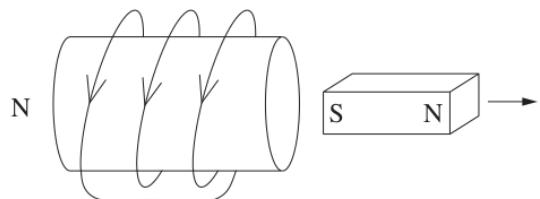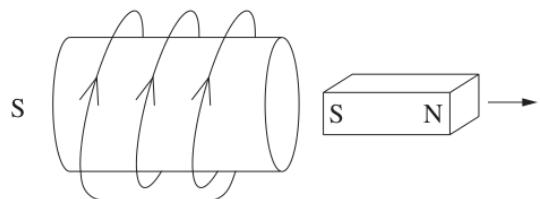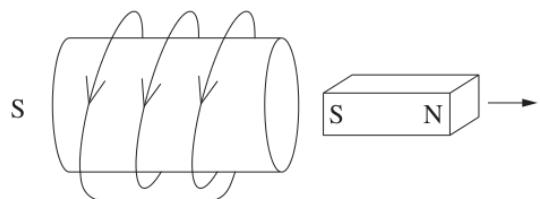
Question 8

8   A typical galaxy has a diameter of 100 000 light years (~30 000 pc).

Which graph is consistent with Hubble's measurements of the recessional velocity of galaxies?

A.

B.

C.

D.
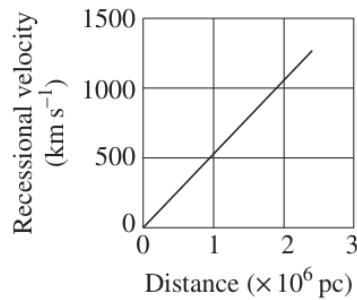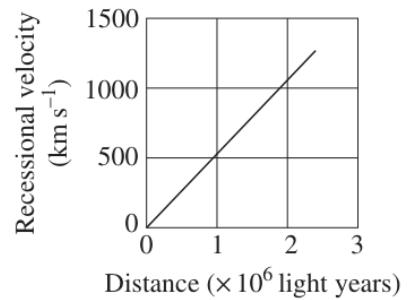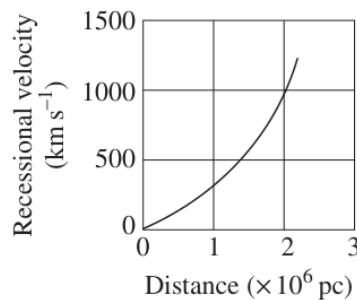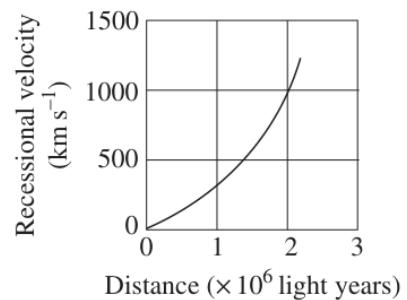
Question 9

9   Two satellites have the same mass. One (LEO) is in low-Earth orbit and the other (GEO) is in a geostationary orbit.

The total energy of a satellite is half its gravitational potential energy.

Which row of the table correctly identifies the satellite with the greater orbital period and the satellite with the greater total energy?

	Greater orbital period	*Greater total energy*
A.	LEO	LEO
B.	LEO	GEO
C.	GEO	LEO
D.	GEO	GEO

Figure 9: Q9

Question 10

10 A beam of light passes through two polarisers. The second polariser has a transmission axis at an angle of 30° to that of the first polariser. The intensity of the light beam before and after the second polariser is I_0 and I_B respectively.
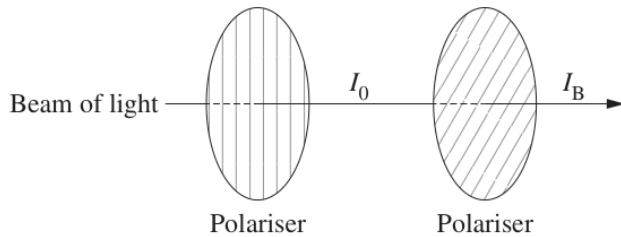
Which row of the table correctly identifies the value of $\dfrac{I_B}{I_0}$, and the model of light demonstrated by this investigation?

	Value of $\dfrac{I_B}{I_0}$	Model of light demonstrated
A.	0.750	Wave model
B.	0.750	Particle model
C.	0.866	Wave model
D.	0.866	Particle model

Figure 10: Q10

Question 11

11 A dwarf planet orbits the sun with a period of 40 000 years.

The average distance from the sun to Earth is one astronomical unit.

What is the average distance between this dwarf planet and the sun in astronomical units?

A. 34
B. 200
C. 1170
D. 8×10^6

Figure 11: Q11

Question 12

12 The table shows two types of quarks and their respective charges.

Quark	Symbol	Charge
Up	u	$+\dfrac{2}{3}$
Down	d	$-\dfrac{1}{3}$

In a particular nuclear transformation, a particle having a quark composition udd is transformed into a particle having a quark composition uud.

What is another product of this transformation?

A. Electron
B. Neutron
C. Positron
D. Proton

Figure 12: Q12

Question 13

13 A laser has a power output of 30 mW and emits light with a wavelength of 650 nm.

How many photons does this laser emit per second?

A. 4.6×10^{14}

B. 9.8×10^{16}

C. 3.1×10^{19}

D. 9.3×10^{21}

Figure 13: Q13

Question 14

14 A satellite in circular orbit at a distance r from the centre of Earth has an orbital velocity v.

If the distance was increased to $2r$, what would be the satellite's orbital velocity?

A. $\dfrac{v}{2}$

B. $0.7v$

C. $1.4v$

D. $2v$

Figure 14: Q14

Question 15

15   Monochromatic light passes through two slits $1\,\mu m$ apart. The resulting diffraction pattern is measured at a distance of 0.3 m.
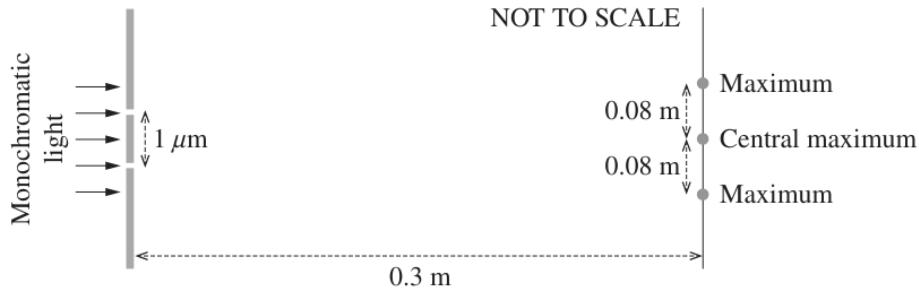
This diffraction pattern can be analysed using the equation $d\sin\theta = \lambda$.

What values of d and θ should be used in the equation?

	d	θ
A.	0.3 m	$\tan^{-1}\left(\dfrac{0.08}{0.3}\right)$
B.	0.3 m	$\sin^{-1}\left(\dfrac{0.08}{0.3}\right)$
C.	$1\,\mu m$	$\tan^{-1}\left(\dfrac{0.08}{0.3}\right)$
D.	$1\,\mu m$	$\sin^{-1}\left(\dfrac{0.08}{0.3}\right)$

Figure 15: Q15

14

Question 16

16 The diagram shows the trajectory of a particle with charge q and mass m when fired horizontally into a vacuum chamber, where it falls under the influence of gravity.
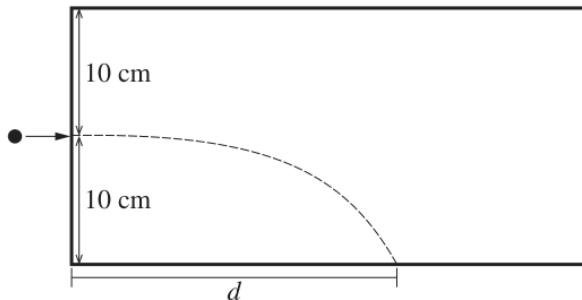
The horizontal distance, d, travelled by the particle is recorded.

The experiment is repeated with a uniform vertical electric field applied such that the particle travels the same horizontal distance, d, but strikes the upper surface of the chamber.
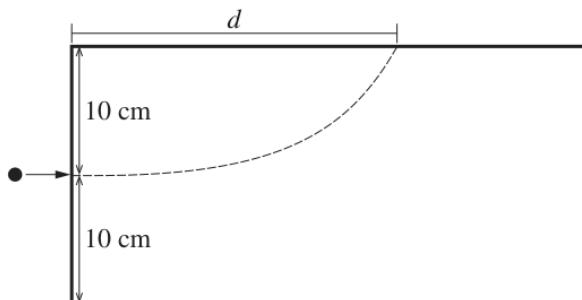
What is the magnitude of the electric field?

A. mgq

B. $2mgq$

C. $\dfrac{mg}{q}$

D. $\dfrac{2mg}{q}$

Question 17

17 A straight current-carrying conductor, *QR*, is connected to a battery and a variable resistor. *QR* is enclosed in an evacuated chamber with a fluorescent screen at one end.
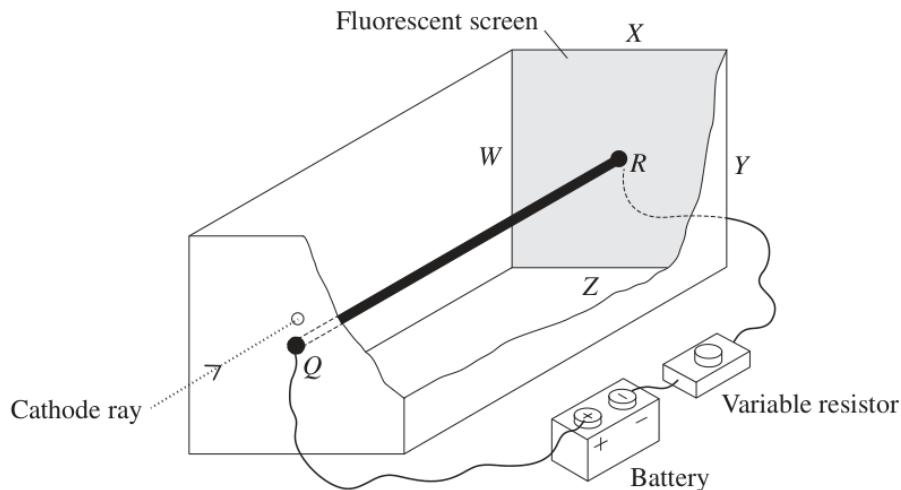
A cathode ray enters the chamber directly above *Q*, initially travelling parallel to *QR*. It passes through the chamber and strikes the fluorescent screen causing a bright spot.

Which direction will this spot move towards if the resistance is increased?

A. *W*

B. *X*

C. *Y*

D. *Z*

Question 18

18 A circular loop of wire is connected to a battery and a lamp. The apparatus is moved from
P to Q along the path shown at a constant velocity through a region containing a uniform
magnetic field.
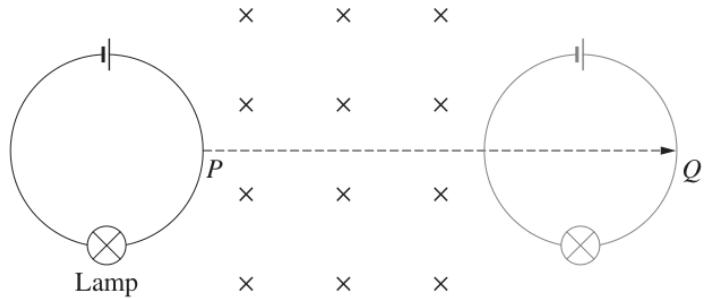
Which graph shows the brightness of the lamp as the apparatus moves between P and Q?

A.

B.

C.

D.
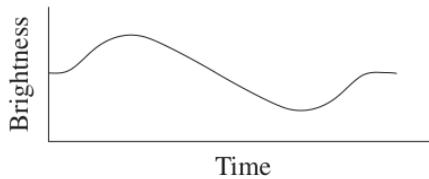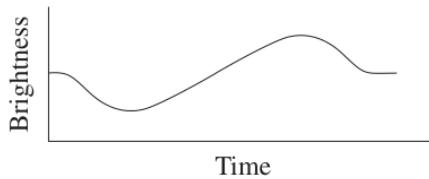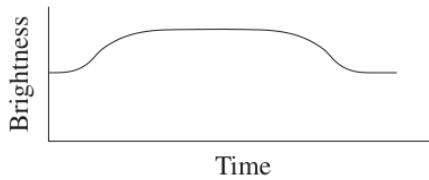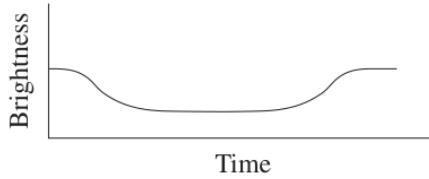
Question 19

19   Consider the following nuclear reaction.

$$W + X \rightarrow Y + Z$$

Information about W, X and Y is given in the table.

Species	Mass defect (u)	Total binding energy (MeV)	Binding energy per nucleon (MeV)
W	0.00238817	2.224566	1.112283
X	0.00910558	8.481798	2.827266
Y	0.03037664	28.29566	7.073915

Which of the following is a correct statement about energy in this reaction?

A.   The reaction gives out energy because the mass defect of Y is greater than that of either W or X.

B.   It cannot be deduced whether the reaction releases energy because the properties of Z are not known.

C.   The reaction requires an input of energy because the mass defect of the products is greater than the sum of the mass defects of the reactants.

D.   Energy is released by the reaction because the binding energy of the products is greater than the sum of the binding energies of the reactants.

Question 20

20   In the apparatus shown, a backboard is connected by a rod to a shaft. The shaft is spun by an electric motor causing the backboard to rotate in the horizontal plane around the axis X–X′.

A cube is suspended by a string so that it touches the surface of the backboard.
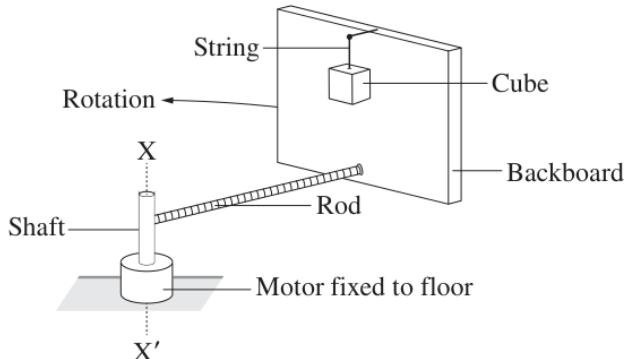
When the angular velocity of the motor is great enough, the string is cut and the position of the cube does not change relative to the backboard.

Which statement correctly describes the forces after the string is cut?

A.   The sum of the forces on the cube is zero.

B.   The horizontal force of the backboard on the cube is equal in magnitude to the horizontal force of the cube on the backboard.

C.   The horizontal force of the backboard on the cube is greater than the horizontal force of the cube on the backboard, resulting in a net centripetal force.

D.   The force of friction between the cube and the backboard is independent of the force of the backboard on the cube because these forces are perpendicular to each other.

Section II: Extended Response

80 marks - Questions 21-36

Allow about 2 hours and 25 minutes for this section

Question 21 (2 marks)

Question 21 (2 marks)

Outline de Broglie's contribution to quantum mechanics. Support your answer with a relevant equation.　　2

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Figure 21: Q21

Question 22 (3 marks)

Question 22 (3 marks)

Spectra can be used to determine the chemical composition and surface temperature of stars.   **3**

Describe how spectra provide information about OTHER features of stars.

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Figure 22: Q22

Question 23 (3 marks)

A student investigated the photoelectric effect. The frequency of light incident on a metal surface was varied and the corresponding maximum kinetic energy of the photoelectrons was measured.

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The following results were obtained.

Frequency ($\times 10^{14}$ Hz)	11.2	13.5	15.2	18.6	20.0
Maximum kinetic energy (eV)	0.6	1.3	2.3	3.3	4.2

Plot the results on the axes below and hence determine the work function of the metal in electron volts.

Figure 23: Q23

Question 24 (7 marks)

Question 24 (7 marks)

A step-up transformer is constructed using a solid iron core. The coils are made using copper wires of different thicknesses as shown.
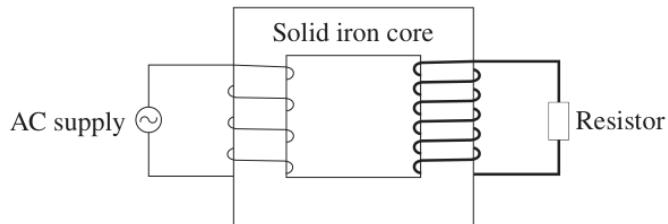
The table shows electrical data for this transformer.

V_s	I_s	$V_p I_p$
50 V	9 A	500 J s^{-1}

(a) Explain how the operation of this transformer remains consistent with the law of conservation of energy. Include a relevant calculation in your answer.

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(b) Explain how TWO modifications to this transformer would improve its efficiency.

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Figure 24: Q24

Part (a)

(a) Explain how the operation of this transformer remains consistent with the law of conservation of energy. Include a relevant calculation in your answer.

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Figure 25: Q24a

Part (b)

(b) Explain how TWO modifications to this transformer would improve its efficiency.

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Figure 26: Q24b

Question 25 (4 marks)

The diagram shows a model of electromagnetic waves.   4

E

Oscillating
charge

$(+)$

B

Propagation
direction

v

Relate this model to predictions made by Maxwell.

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Please turn over

Figure 27: Q25

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Question 26 (6 marks)

Question 26 (6 marks)

A student carried out an experiment to investigate the relationship between the torque produced by a force and the angle at which the force is applied. A 400 N force was applied to the same position on the handle of a spanner at different angles, as shown.
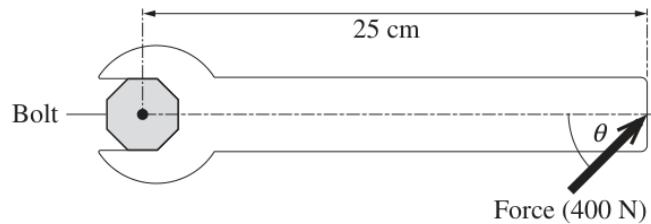
A high-precision device measured the torque applied to the bolt.

The data from the experiment is graphed below.

Figure 28: Q26

26

Part (a)

(a) Justify the validity of the student's model using information from the graph. **3**

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Figure 29: Q26a

Part (b)

(b) What happens to the accuracy of this model's predictions as the angle increases beyond 25°? Justify your answer with reference to a different model. **3**

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End of Question 26

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Figure 30: Q26b

Question 27 (6 marks)

(a)   Outline a thought experiment that relates to the prediction of time dilation.   **3**

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(b)   Outline experimental evidence that validated the prediction of time dilation.   **3**

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Figure 31: Q27
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Question 28 (3 marks)

A metal loop, *WXYZ* is connected to a battery and placed in a uniform magnetic field. A current flows through the loop in the direction shown.

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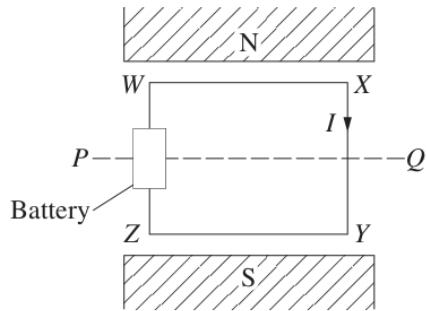
The loop is then allowed to rotate by 90° about the axis *PQ*.

Compare the forces acting on *WX* and *XY* before and after this rotation.

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Figure 32: Q28
29

Question 29 (3 marks)

A particle having mass m and charge q is accelerated from rest through a potential difference V. Assume that the only force acting on the particle is due to the electric field associated with this potential difference.

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Show that the final velocity of the particle is given by $v = \sqrt{\dfrac{2qV}{m}}$.

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Figure 33: Q29
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Question 30 (6 marks)

A ball, initially at rest in position P, travels along a frictionless track to point Q and then falls to strike the floor below.

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SCALE
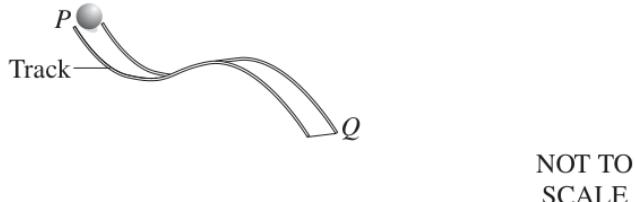
At the instant the ball leaves the track at Q it has a velocity of 1.5 m s^{-1} at an angle of 50° to the horizontal.

(a)   Calculate the difference in height between P and Q.   3

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(b)   The ball takes 0.5 s to reach the floor after leaving the track at Q.   3

Calculate the height of Q above the floor.

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Figure 34: Q30

Part (a)

(a)   Calculate the difference in height between P and Q.   **3**

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Figure 35: Q30a

Part (b)

(b)   The ball takes 0.5 s to reach the floor after leaving the track at Q.   **3**

Calculate the height of Q above the floor.

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Figure 36: Q30b

Question 31 (8 marks)

A student suspends an electric ceiling fan from a spring balance.

The fan is switched on, reaching a maximum rotational velocity after ten seconds.
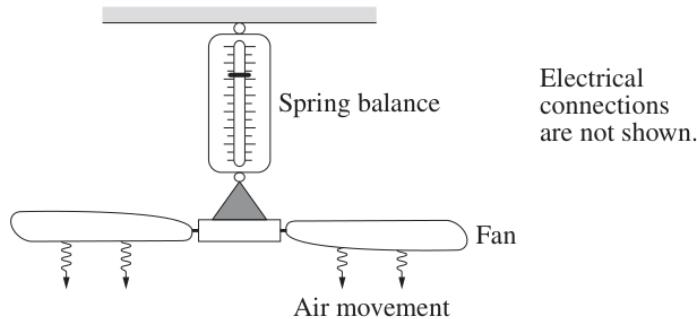
(a)   Explain the changes that would be observed on the spring balance in the first   **4**
15 seconds after the fan is switched on.

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Question 31 continues on page 29

Figure 37: Q31

Part (b)

(b) The student predicted that the current through the fan's motor would vary as   **4**
shown on the graph.

Current

0   5   10   15

Time (s)
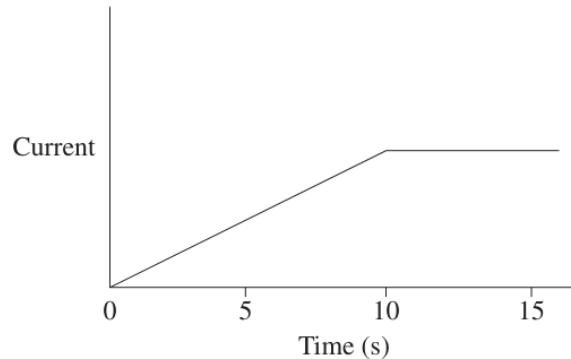
Assess the accuracy of the student's prediction.

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End of Question 31

Figure 38: Q31b

Question 32 (5 marks)

Describe how specific experiments have contributed to our understanding of the electron and ONE other fundamental particle.

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Figure 39: Q32

Question 33 (4 marks)

A proton and an alpha particle are fired into a uniform magnetic field with the same speed from opposite sides as shown. Their trajectories are initially perpendicular to the field.

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Proton →

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× × × × × ×

× × × × × ×

× × × × × ×

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× × × × × ×

← Alpha particle

Explain ONE similarity and ONE difference in their trajectories as they move in the magnetic field.

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Figure 40: Q33

Question 34 (9 marks)

Use the following information to answer this question.

9

Earth's distance from the sun, r .... 1.5×10^{11} m
Intensity of solar radiation at a distance r from the sun .... 1360 W m^{-2}
Surface area of a sphere .... $4\pi r^2$

Radiation curve for the sun

Intensity

400   500   600   700

Wavelength (nm)
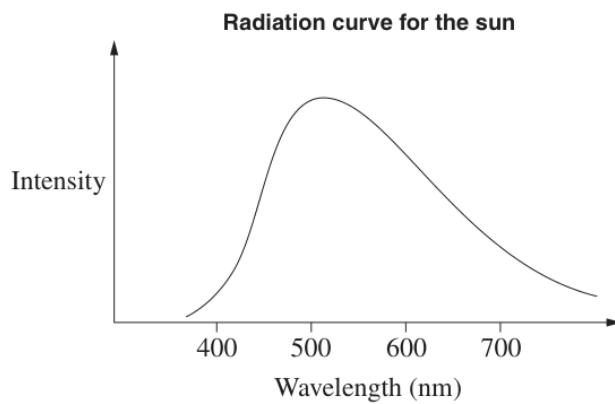
Describe both the production and radiation of energy by the sun. In your answer, include a quantitative analysis of both the power output and the surface temperature of the sun.

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Figure 41: Q34

Question 35 (4 marks)

The apparatus shown is attached horizontally to the roof inside a stationary car. The plane of the protractor is perpendicular to the sides of the car.

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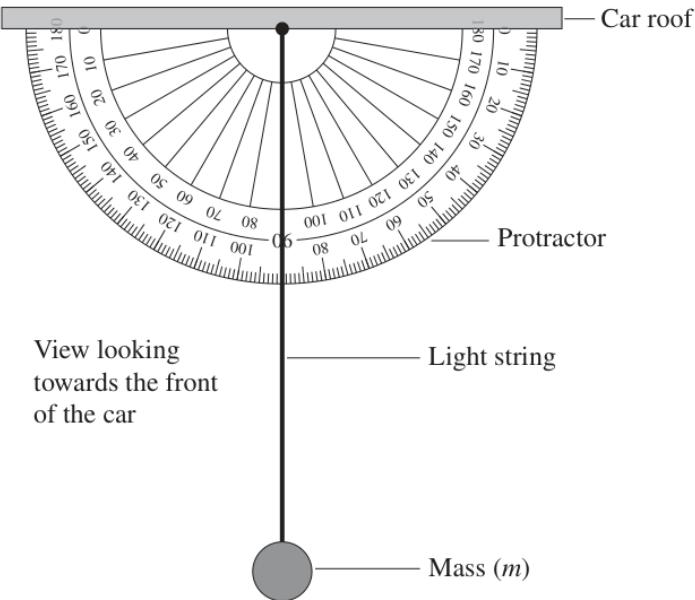
The car was then driven at a constant speed (v), on a horizontal surface, causing the string to swing to the right and remain at a constant angle (θ) measured with respect to the vertical.

Describe how the apparatus can be used to determine features of the car's motion. In your answer, derive an expression that relates a feature of the car's motion to the angle θ.

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Figure 42: Q35

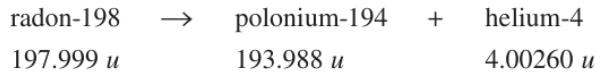**Question 36** (7 marks)

A radon-198 atom, initially at rest, undergoes alpha decay. The masses of the atoms involved are shown in atomic mass units (u).   **7**

$$\text{radon-198} \quad \rightarrow \quad \text{polonium-194} \quad + \quad \text{helium-4}$$
$$197.999\ u \qquad\qquad 193.988\ u \qquad\qquad 4.00260\ u$$

The kinetic energy of the polonium atom produced is 2.55×10^{-14} J.

By considering mass defect, calculate the kinetic energy of the alpha particle, and explain why it is significantly greater than that of the polonium atom.

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End of paper

Figure 43: Q36