P12 Trials

B12 Trial

Baulkham Hills High School

Higher School Certificate

Trial Examination

2011

Physics

GENERAL INSTRUCTIONS

- Reading time - 5 minutes
- Working time - 3 hours
- Write your Candidate Number in the spaces indicated
- Board approved calculators may be used
- Write using black or blue pen only
- Draw diagrams using pencil
- A data sheet, Formulae Sheets and Periodic Table are provided at the back of this paper
- Students should show all working

TOTAL MARKS: 100

SECTION I
75 marks
This section has TWO parts, Part A and Part B

Part A – Multiple Choice
(20 marks)
Questions 1-20
Allow about 30 minutes for this section

Part B – Extended Response
(55 marks)
Questions 21-32
Allow about 2 hours for this section

SECTION II
25 marks
Elective – Astrophysics
Question 33
Allow about 30 minutes for this section

Section I
75 marks

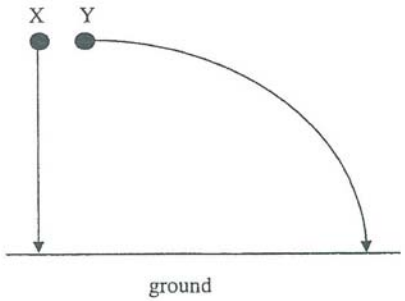
Part A – Multiple Choice (20 marks)
Attempt Questions 1-20
Allow about 30 minutes for this section

Select the alternative, A, B, C or D which best answers the question and indicate your choice with an 'X' on the Multiple Choice Answer Sheet.

1. Why do all objects at any particular point on the Earth's surface accelerate at the same rate in free fall?

   a) The gravitational force acting on each object is the same
   b) The gravitational force on each object is proportional to its mass
   c) The acceleration is directly proportional to the gravitational force acing on each mass
   d) The acceleration is directly proportional to the mass of each object

2. Two identical metal balls, X and Y are released at the same time from the same height above horizontal ground. Ball X falls vertically from rest. Ball Y is projected horizontally as shown below. (Air resistance is negligible).



   Which of the following statements is correct?

   a) Ball X hits the ground before Ball Y because it travels a shorter distance
   b) Ball Y hits the ground before Ball X because its initial velocity is greater
   c) The balls hit the ground at the same time because horizontal motion does not affect vertical motion
   d) The balls hit the ground at the same time because they have equal weights

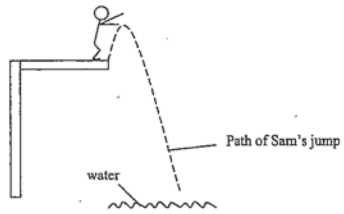
3. Which of the following best describes the function of the brushes in an electric motor?

   a) The brushes keep the commutator clean
   b) The brushes are there to allow the back EMF to flow
   c) The brushes act as a bearing for the rotating part of the motor
   d) The brushes are conductors that allow electric current to flow through the rotor

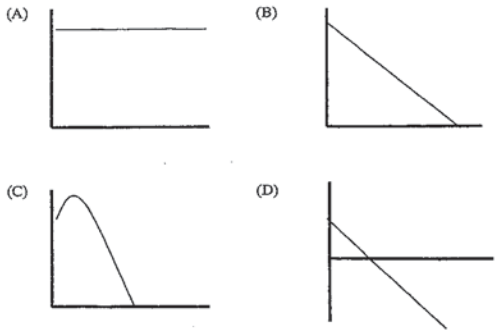
4. Cathode rays can be readily manipulated to trace a signal on the display of a cathode ray oscilloscope because

a) cathode rays are a form of electromagnetic radiation which is sensitive to gravitational fields
b) cathode rays are positively charged particles that magnetic fields will deflect
c) cathode rays are a stream of electrons that can be directed by electric and magnetic fields
d) cathode rays will pass through transparent materials like glass, unimpeded

5. In the diagram below, Sam is on a diving board above the water, ready to jump. He jumps with an initial vertical speed of 21.5/ms up before landing in the water.



Which of the graphs below best describes how Sam's vertical velocity changes with time?



6. Which of the following is NOT due to the motor effect?

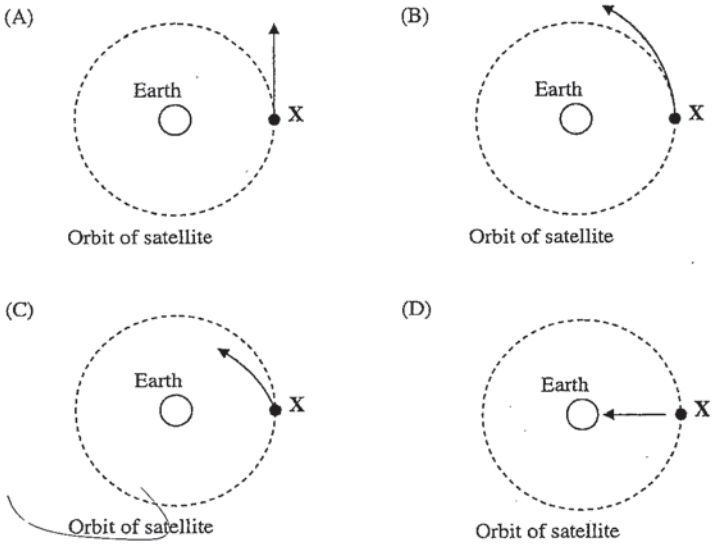
a) Rotation of a coil in a generator
b) Movement of a needle in a galvanometer
c) Movement of the voice coil in a loud speaker
d) Electromagnetic brakes

7. Identify a situation in which the statement '*the two events occurred at the same time*' has meaning.

a) the observer is moving past the two events
b) The observer is in a different frame of reference to the two events
c) The events and the observer are in the same frame of reference
d) The observer is not moving while the two events are moving past

8. *A satellite is in a stable geostationary orbit around the Earth.*

Which choice best shows the satellite's path (solid arrow) if the gravitational force acting on it was somehow "switched off" when it was at point X?



9. A proton enters a magnetic field as part of an experiment running in a particle accelerator.

The proton enters the magnetic field from the left as shown below.

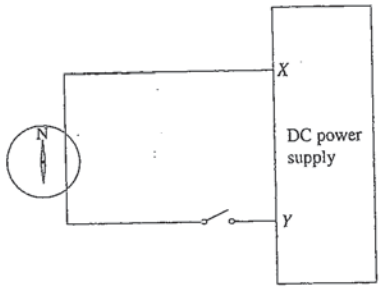
What is the direction of the force on the proton when it enters the field?

a) To the bottom of the page
b) To the top of the page
c) Out of the page
d) Into the page

10. In a DC motor, a current carrying conductor rotates in a magnetic field. While a voltage is supplied to the motor and the motor is rotating, which would be a correct observation?

a) The net emf would increase
b) The supply emf would decrease
c) The current in the coil would be greater while it is stationary than when it was turning
d) An induced current would be generated in the same direction to the supply current

11. A copper wire connected through a switch to a power supply is placed over a compass needle as shown below, where the arrow head is pointing north.



When the switch is closed you would expect the needle to

a) deflect clockwise when terminal *X* on the power supply is positive
b) deflect clockwise when terminal *X* on the power supply is negative
c) deflect anticlockwise when terminal *X* on the power supply is positive
d) not move at all because any magnetic field produced is along the wire

12. Heinrich Hertz conducted a number of experiments into the nature of radio waves.

Which one of the following did Hertz NOT investigate?

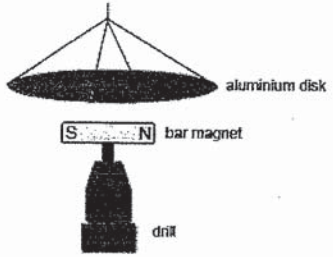
a) The polarising of radio waves
b) The speed of radio waves
c) The wavelengths of radio waves
d) The photoelectric effect caused by radio waves

13. The weight of a one tonne space craft on Earth is 9800 N and the weight of the same space craft on Mars is 3800 N.

What is the acceleration due to gravity on Mars?

a) 1.8 ms^{-2}
b) 3.8 ms^{-2}
c) 5.8 ms^{-2}
d) 9.8 ms^{-2}

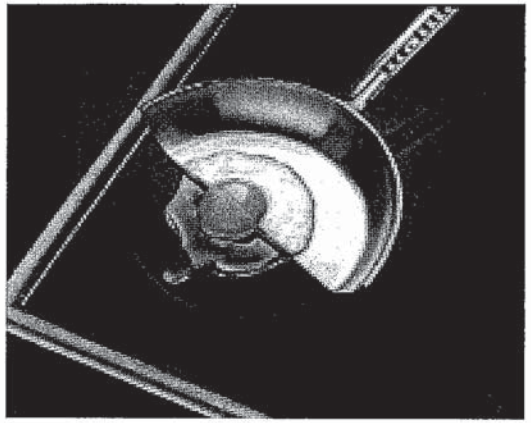
14. A magnet was attached to an electric drill. The apparatus was held beneath an aluminium metal disk that was suspended by fine nylon wire from above, as shown below.



When the drill was turned on, the disk was observed to spin. This experiment demonstrates the principle of

a) an AC induction cook top
b) an AC loudspeaker
c) an AC induction motor
d) an AC galvanometer

15. An induction cooktop is switched on HIGH and an egg is cracked on the surface. Half of the egg is in a pan and the other half is on the cooktop, as shown. After some minutes, the part of the egg in the pan is perfectly cooked whereas the part on the cooktop is still raw.



The reason for this is because

a) eddy currents are induced in the metal frypan
b) eddy currents are induced in the egg
c) raw egg is not a good conductor of electricity
d) heat from the cooktop is easily conducted to the egg by the frypan

16. Which choice correctly describes *escape velocity?*

    a) The velocity an object needs to be given at the Earth's surface to escape completely from the gravitational field of the planet
    b) The velocity an object needs to be given at launch from the Earth's surface to enter a geostationary orbit about the planet
    c) The velocity an object needs to be given to escape from the atmosphere of the planet
    d) The velocity an object needs to be given to cancel the effects of gravity

17. Which of the following correctly describes the function of a step-up transformer connected between a power station generator and the high voltage distribution line?

    a) The transformer steps up the voltage to make up for the voltage drop in the power lines
    b) The transformer separates the power lines from the generator so electricity cannot flow back into the generator
    c) The transformer reduces the current needed for the same amount of power thereby reducing the heating losses in the powerlines
    d) The transformer stops any direct current from entering the AC power lines

18. In one experiment carried out on the space station, a small satellite was lowered from the space station on a strong conducting wire so that it orbited Earth with the space station, but was tethered 5km below it. It was noted that the satellite became strongly negatively charged relative to the space station.

    Which of the following statements below best describes the reason for this negative charge?

    a) The Earth has a strong electric field
    b) The wire was moving across the Earth's magnetic field
    c) The wire was moving along the Earth's magnetic field
    d) The wire was moving through the Van Allen radiation belts

19. Electricity for a power plant whose power input is 280MW is generated at 25kV then increased to 330kV.

    What is the current in the secondary coil if the transformer is 100% efficient?

    a) 0.85 A
    b) 8.48 A
    c) 84.8 A
    d) 848 A

20. Some of the more energetic gamma rays which enter the Earth's atmosphere from cosmic sources have wavelengths of 1×10^{-13} m.

    Measured in joules, what would be the energy of a single photon with this wavelength?

    a) 6.626×10^{-47} J
    b) 1.9878×10^{-38} J
    c) 3×10^{21} J
    d) 1.9878×10^{-12} J

End of Part A

Candidate Number: ..... Teacher: .....

Section I (continued)

Part B (55 marks)
Attempt Questions 21-32
Allow about 1 hour and 35 minutes for this part

Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

Marks

Question 21 (5 marks)

The radius of the Earth is 6.38×10^6 m. A satellite is in orbit at an altitude of 38 000 km.

a) Calculate the gravitational potential energy (GPE) of a satellite of mass 1700kg at this altitude. **2**

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b) Calculate the GPE of the satellite at the Earth's surface. **2**

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c) Outline how you could use the values in parts (a) and (b) to calculate the energy needed to lift the satellite to this altitude. **1**

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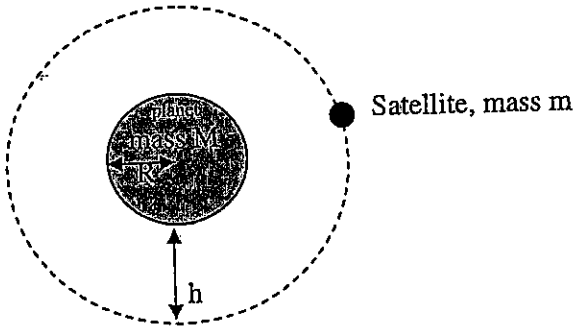
Marks

Question 22 (5 marks)

A spherical planet has radius R and mass M. A satellite of mass m orbits the planet with constant orbital speed v at a height h above the planet's surface as shown below (not to scale).



a) Outline why, although the satellite is moving with constant speed, the net force on it is not zero. **1**

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b) Why does a person experience weight on the Earth but feel weightless orbiting the Earth in a satellite? **2**

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c) A second satellite, mass 2M, is placed into the same orbit. What will be its orbital speed compared to the first satellite? **2**

Justify your answer using Physics equations.

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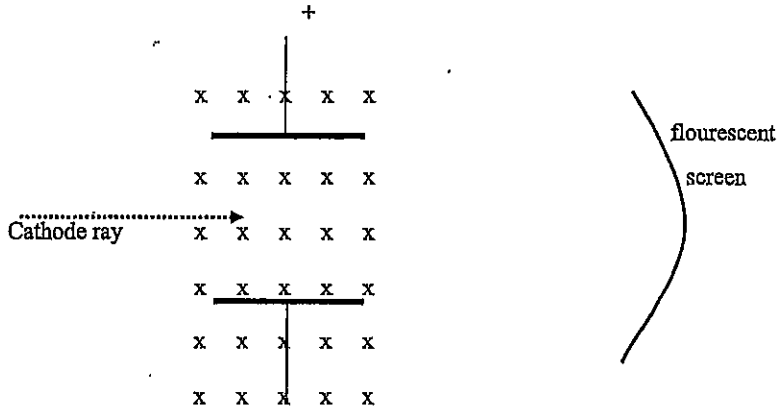
Question 23 (7 marks)

The diagram below is of the apparatus used by J J Thompson to measure some of the properties of cathode rays. The cathode ray is fired at high velocity across both magnetic and electric fields and the deflection is measured on a fluorescent screen.

Marks



a) On the diagram above, indicate the direction of the force experienced by the cathode rays when only the magnetic field is applied. 1

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b) In one of his experiments, J J deflected a cathode ray travelling at 0.01c by passing it through a magnetic field of 0.01T. Calculate the force acting on the cathode ray, due to the magnetic field. 2

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c) In his next experiment, J J also applied an electric field of 300V across the parallel plates, 1cm apart. Calculate the net force on the cathode ray. 2

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d) In 1897, why was J J Thompson's experiment and results regarded as a "scientific breakthrough?" 2

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Question 24 (5 marks)

Students experimenting with a small electric motor measure the current through it as the voltage connected to it is changed. The source of current is a small DC power supply with a switch that can be rotated to supply different voltages. The motor just starts to move during the first reading at 1 V and is spinning rapidly when they take the reading at 11 V.

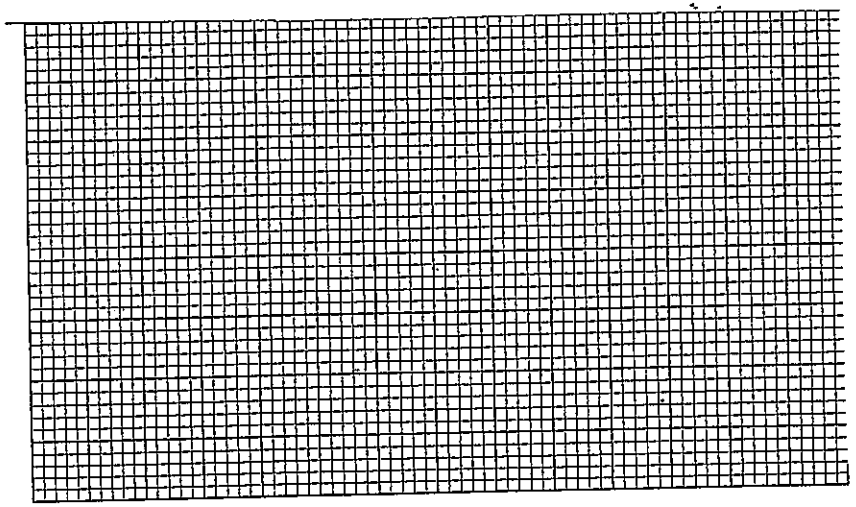
One student then stops the motor by tightly holding the output shaft then, when smoke pours from the motor, he releases it in surprise and the circuit breaker on the power supply operates.

The results are shown in the table below.

Potential difference (V)	Current (A)
1	0.4
2.1	0.9
3.5	1.5
4.7	1.9
6.2	2.5
7.5	2.5
9	2.8
11	2.9

Marks

a) Plot these data points on the axes below. 2



b) Sketch an appropriate line of best fit on the graph. 1

c) Outline why the motor produced smoke or why the circuit breaker activated. 2

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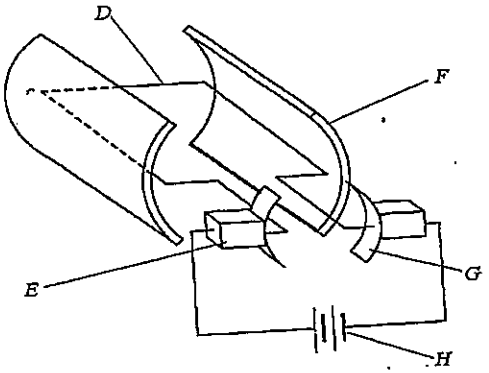
Marks

Question 25 (4 marks) 4

Draw a table that summarises the following information:

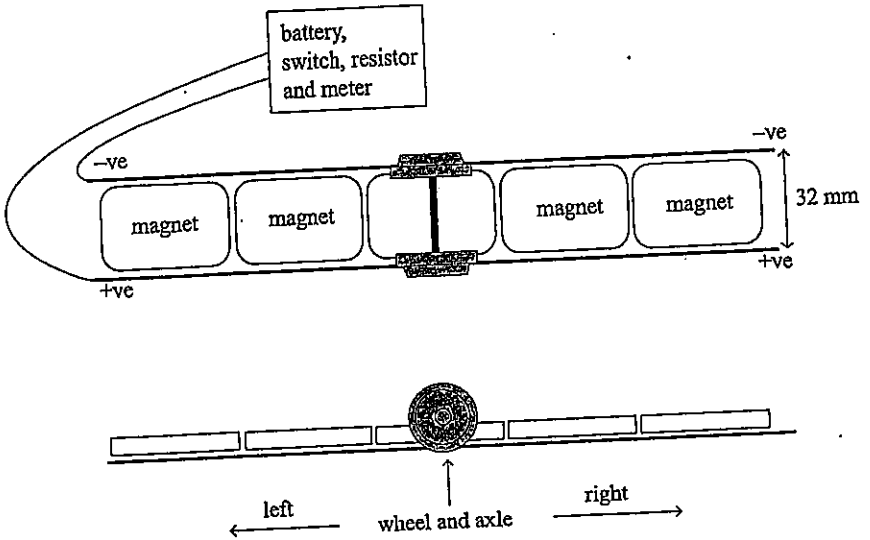
- the identification of components *D, E, F, G* and *H*
- the function of each component



Marks

Question 26 (3 marks)

In an experiment to investigate magnetic fields and currents, the metal wheels and axle from a model railway were placed on a set of rails as shown below. Between the rails were a series of block magnets placed so their north poles were pointing up. The rails, which were 32mm apart, were connected to a 12V battery through a switch, a 1ohm resistor and an Ammeter. When the switch was closed, a current of 11 amps flowed through the circuit and the wheel and axle started to move.



a) If the polarity of the power was as shown above, which way would the wheel and axle start to move? 1

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b) If the magnetic field strength in the region of the axle was 0.1T, what force would be acting on the axle due to the interaction of the magnetic field and the current through it.? 2

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Marks

Question 27 (6 marks)

a) Titan and Rhea are moons orbiting Saturn. Titan orbits at a distance of 1.2×10^6 km from the centre of Saturn. 2

Given that Titan takes exactly three times as long as Rhea to orbit Saturn, calculate the mean distance between the centres of Rhea and Saturn.

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b) Given that the mass of Saturn is 5.68×10^{26} kg, calculate the orbital velocity of Rhea. 2

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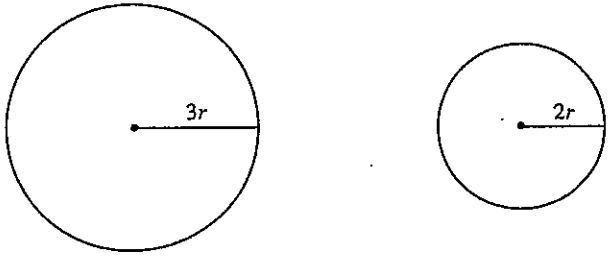
c) Two new moons of Saturn are discovered. One of the new moons, Cupid, has a mass of $3m$ and a radius of $3r$ while the other new moon, Zeus, has a mass of m and a radius of $2r$, as shown in the diagram below.



If the acceleration due to gravity on the surface of Cupid is 1.0 ms^{-2}, what is the acceleration due to gravity on the surface of Zeus?

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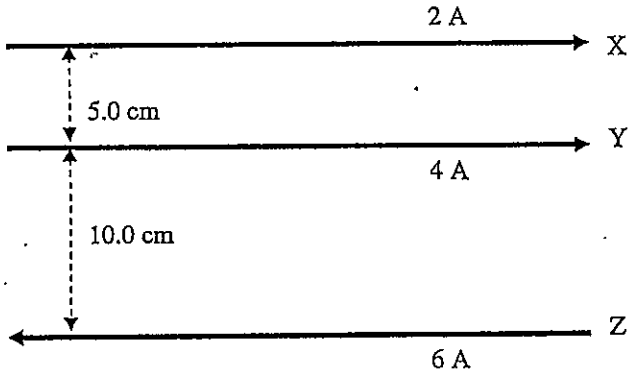
Marks

Question 28 (3 marks)

Three long, straight, parallel wires, X, Y and Z are 5.0 cm and 10.0 cm apart respectively and carry currents of 2A, 4A and 6A. The currents in wires X and Y are in the opposite direction to the current in wire Z.



Calculate the magnitude AND direction of the force per unit length on wire Y, due to the other two wires.

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Marks

Question 29 (4 marks)

The Large Hadron Collider sends beams of protons around the 27km long circular tunnel 11 000 times each second.

a) How fast are the protons travelling? 1

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b) What would an observer outside the Large Hadron Collider determine the mass of the proton to be whilst travelling at this speed? 3

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Question 30 (3 marks)

The impact of the development of transformers on society has been enormous. Electrical energy from coal fired power stations is distributed to homes and industries at great distances from its point of generation using transformers. 3

Transformers are also a point of energy losses. Explain how these energy losses occur in transformers and how they can be reduced.

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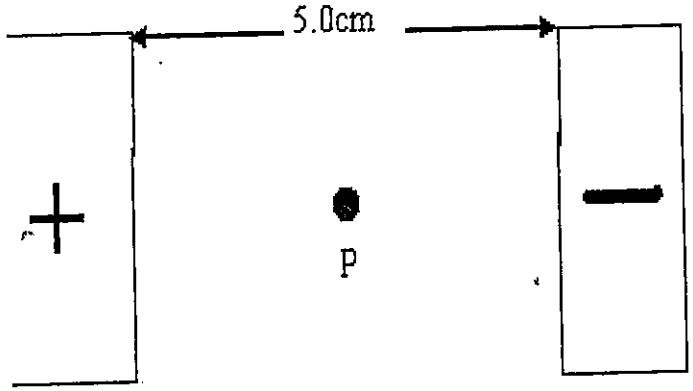
Marks

Question 31 (4 marks)

Two parallel plates with a potential difference of 10 000V are placed at a distance of 5.00 cm apart.



a) Draw the electric field between the TWO plates. 1

b) A small test particle of mass 1.0×10^{-20} kg is given a positive charge of 3.2×10^{-10}C and placed at the point P, midway between the two plates. 3

What would be the acceleration (magnitude and direction) of the test particle?

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Marks

Question 32 (6 marks)

Explain how results of blackbody radiation experiments and the photoelectric effect experiments led to a change in the model of light. 6

End of Part B

Candidate Number: ..... Teacher: .....

Section II
25 marks
Elective: Astrophysics

Attempt Question 33
Allow about 30 minutes for this part
Write your answers in the spaces provided.

Marks

Question 33 – Astrophysics (25 marks)

a) i) Distinguish between absolute and apparent magnitude. 2

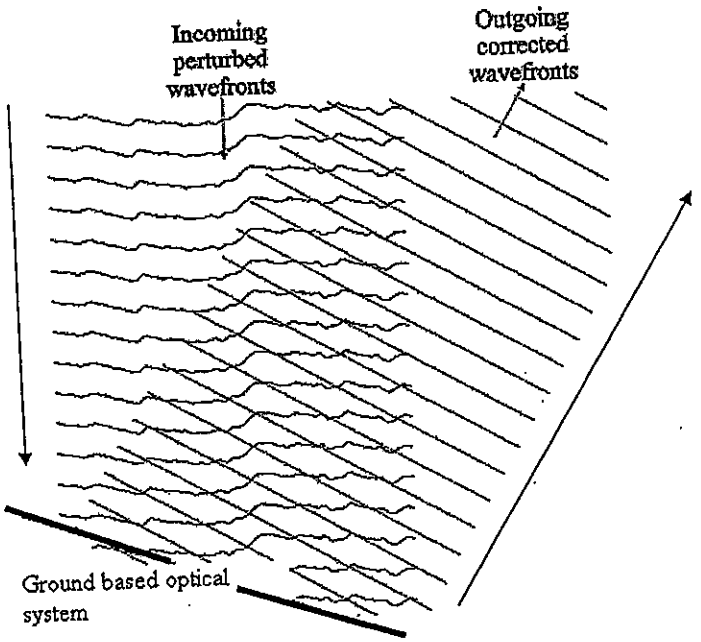
ii) Calculate the apparent magnitude of a star that is 30 times fainter than another star of apparent magnitude 3.2. 3

Question 33 continued on page 21

Marks

Question 33 (continued)

b) i) The diagram shows incoming light waves from a star affected by atmospheric distortion before and after correction.



Outline how a ground based optical system is able to compensate for atmospheric distortion. 4

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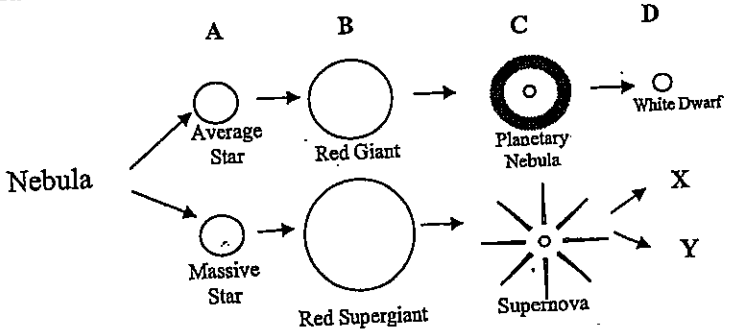
Question 33 continues on page 22

Marks

Question 33 (continued)

c) The flow chart below shows the life cycle of two types of stars.



i) Identify X and Y. 1

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ii) Outline the differences between the nuclear reactions occurring in the average and massive star during stage A, B and C in their life cycles. 3

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d) i) Determine the angle of parallax that would be made in order to measure the distance to a star that is 220 parsecs away. 1

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Question 33 continues on page 23

Marks

Question 33 (continued)

d) ii) Explain whether the measurement for this star was taken from Earth or space. 2

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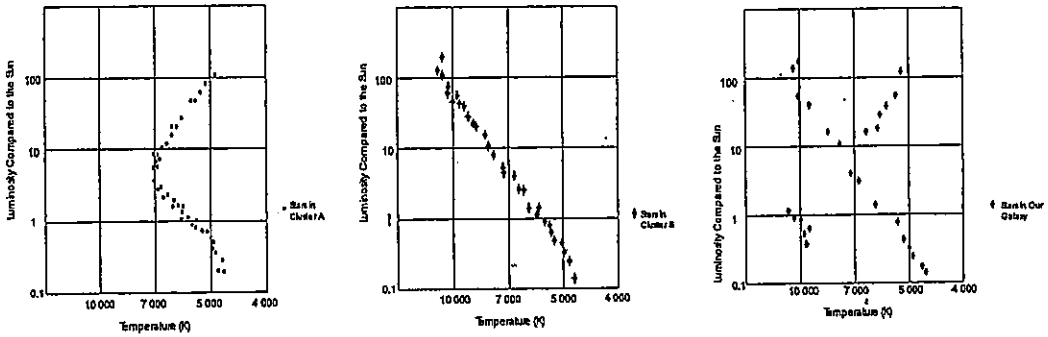
e) The three Hertzsprung-Russell diagrams below represent stars from globular cluster A and cluster B and stars from our own galaxy.



What can you infer about the age of globular cluster A compared to that of cluster B? 3

Justify your answer.

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Question 33 continued on page 24

Marks

Question 33 (continued)

f) 'The study of binary and variable stars reveals vital information about stars.' 6

Justify this syllabus statement.

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End of Paper

Solutions / Marking Scheme

BHHS 2011 Physics HSC Trial

Section I – Part A
Multiple Choice Answer Sheet

1				D
2	A	B		D
3	A	B	C	
4	A	B		D
5	A	B	C	
6		B	C	D
7	A	B		D
8		B	C	D
9	A		C	D
10	A	B		D

11		B	C	D
12	A	B	C	
13	A		C	D
14	A	B		D
15		B	C	D
16		B	C	D
17	A	B		D
18	A		C	D
19	A	B	C	
20	A	B	C	

Q 21. (a)

$E_p = -(Gm_1m_2)/r$

$= -(6.67 \times 10^{-11} \times 6 \times 10^{24} \times 1700) / (38 \times 10^6 + 6.38 \times 10^6)$

$= -1.53 \times 10^{10}$ J

criteria	mark
Selects the correct equation, including the negative sign Uses the correct numerical values(adds altitude and radius) Converts kilometre to metre Gives correct numerical answer with the appropriate unit (J)	2
As above, but no conversion of kilometre to metre	1
Uses incorrect equation, (mgh) Correct unit used	0

Q21 (b)

$E_p = -(Gm_1m_2)/r$

$= -(6.67 \times 10^{-11} \times 6 \times 10^{24} \times 1700) / 6.38 \times 10^6$

$= -1.07 \times 10^{11}$ J

criteria	mark
Uses the correct equation, including the negative sign Converts kilometre to metre Gives correct numerical answer and unit (J)	2
As above, but no conversion of kilometre to metre	1
Uses incorrect equation (mgh) but with correct unit (J)	0

Q21 (c)

The change in gravitational potential energy, i.e. the difference between the values in (a) and (b), is the energy needed to lift the satellite to the stated altitude.

Criteria	mark
Identifies differences in GPEs means energy needed	1

Q22 (a)

Satellite is accelerating towards the centre(planet)., with the gravtitational force acting on it at 90° to its direction of motion.

criteria	mark
States direction of gravitational force or acceleration in relation to its velocity	1

Q22 (b)

Weight is experienced when our body is in contact with the ground (or any surface) which exerts an upward force on us(pushes on us in the opposite direction to the gravitational force). In orbiting the Earth in a satellite, all parts of our body accelerate at the same rate as the satellite towards Earth due to gravitational force , and no contact forces are exerted on us. Thus there is no sensation of weight.

criteria	mark
Explains sensation of weight and lack of weight in satellite due to common acceleration	2
Explains sensation of weight OR lack of weight in satellite in satellite due to common acccceleration	1

Q22 (c)

It will have the same orbital velocity as the first satellite.

$GMm/r^2 = mv^2/r$, where m = mass of the satellite, M = mass of the planet, r = radius of the orbit

$v = (GM/r)^{1/2}$

Orbital velocity depends on the Mass of the planet

criteria	mark
Provides correct answer and equation to justify it will have the same orbital velocity	2
Provides correct answer OR provides equation to justify same orbital velocity	1
Provides incorrect answer and equation	0

Q23 (a)

Shows that arrow down the page is drawn anywhere within the magnetic field ..... (1 mark)

Q23 (b)

$F = qvB \sin\theta$

$= 1.6 \times 10^{-19} \times 0.01 \times 3 \times 10^5$

$= 4.8 \times 10^{-15}$ N

criteria	mark
Indicates correct equation, substitution and calculation of force Correct unit for force (J)	2
Any one of the above is missing	1

Q23 (c)

$E = V / d$

$= 300V / 0.01m$

$= 30{,}000\ V/m$

$F = qE$

$= 1.6 \times 10^{-19} \times 30{,}0000$

$= 4.8 \times 10^{-15}$ N upwards

$F_{net} = (4.8 \times 10^{-15}\ N \text{ downwards}) + (4.8 \times 10^{-15\ N} \text{ upwards})$

criteria	mark
Selects correct equations and substitution of V and d to calculate F_E AND Adds to answer from part (b) Correct numerical value	2
Selects correct equations and substitution of V and d to calculate F_E Incorrect numerical value	1

Q23(d)

Thomson solved the "particle versus wave" debate by proving that cathode rays are not a form of electromagnetic radiation when he passed them through perpendicular electric and magnetic fields and calculated the velocity of the rays to be less than that of light.

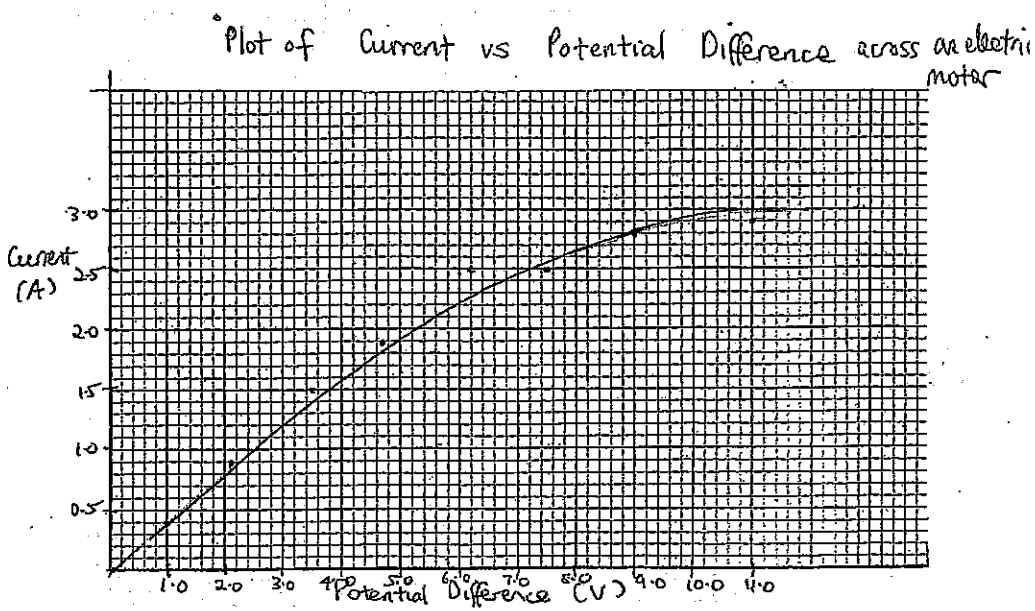
Thomson was also able to find that the charge to mass ratio (q/m) of the rays to be 1800 times larger than that of the smallest ion (i.e. H^+).

He then concluded that these cathode rays are negatively charged particles, which are much smaller than an atom. By using cathodes of different materials, he was able to find that identical rays were produced. Hence he proposed these tiny negatively charged particles (called electrons) were found in all atoms.

This shows that an atom is not indivisible, but is made up of smaller parts.

Criteria	mark
Explains the implications of Thomson's results	2
States Thomson's results **OR** States the particle nature of cathode rays	1

Q24 (a) and (b)



criteria	mark
Axes are correctly labelled, Potential difference along the x-axis Correct units used Suitable scale chosen All points are correctly plotted on the graph	2
Missing any one of the above	1

b) Draws a smooth curve through all except incorrect point.....(1 mark)

Q24(c)

When the motor is running freely, a back emf is induced which acts against the supply emf to limit the current flow in the coil.

When the output shaft is held, there is no longer relative movement between the coil and the motor's magnetic field, so no back emf is induced. The supply emf causes a higher current to flow through the coil, overheats the motor and exceeds the power supply limit.

Criteria	mark
Explain thoroughly the significance of the induced back emf in the operation of an electric motor.	2
Mentions back emf	1

Q25

Component	Name	Function
D	Current-carrying coil **OR** Rotor coil	The coil provides torque when the current passes through it interacts with the external magnetic field.
E	Brush	Carbon rods carry current from the external power source to the split-ring commutator.
F	Circular magnetic pole pieces	Curved surfaces of magnets produce a radial external magnetic field which will always be in the plane of the coil for it to experience uniform torque.
G	Split-ring commutator	It provides points of contact between the rotor coil and the external electric circuit. It serves to reverse the direction of the current flow in the coil every half revolution of the motor to ensure that the torque on the coil is always in the same direction.
H	DC current source	Provides a potential difference (or emf) across the coil (current through coil) for it to experience the motor effect.

Criteria	mark
* Draw a table with appropriate headings * Name all the 5 components correctly * Describes accurately the functions of each component	4
* Draw a table with appropriate headings * Has an error **either** in the identification of the component , **OR** incorrect description of its function OR *all names and functions are correctly stated but the table is not formally constructed.	3
* Draw a table with appropriate headings * Any two incorrect identifications **OR** functions	2
* Draw a table and **one** item correct.	1

Q26 (a)

To the right ..... (1 mark)

Q26 (b)

$F = BIl \sin\theta$

$= 0.1 \times 11 \times 32 \times 10^{-3}$

$= 0.035$ N

criteria	mark
Uses correct equation Correct conversion of mm to m Correct unit (N)	2
Any of the above is incorrect	1

27a) $T_T = 3T_R \qquad r_T = 1.2 \times 10^6$ km

$$\frac{T_T^2}{r_T^3} = \frac{T_R^2}{r_R^3}$$

$$\therefore r_R^3 = \frac{T_R^2}{(3T_R)^2} \times (1.2\times10^6)^3$$

$\therefore r_R = 5.77 \times 10^8$ m or 5.77×10^5 km

Criteria	mark
Calculates correct answer with correct unit	2
Makes a single error in calculation or wrong unit	1

27b) $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$

$$T = \sqrt{\frac{(5.77\times10^8)^3 4\pi^2}{(6.67\times10^{-11})(5.68\times10^{26})}}$$

$T = 4.47 \times 10^5$ s

orbital velocity, $v = \frac{2\pi r}{T}$

$$V = \frac{2\pi (5.77\times10^8)}{4.47\times10^5}$$

$V = 8103\ ms^{-1}$

OR $V = \sqrt{\frac{GM}{r}}$

$$V = \left[\frac{(6.67\times10^{-11})(5.68\times10^{26})}{5.77\times10^8}\right]^{1/2}$$

$V = 8103\ ms^{-1}$

Criteria	mark
calculates correct answer using value of r from (a), with correct unit	2
makes an error / wrong unit	1

27c)

$m_C = 3m$ $\quad m_Z = m$

$r_C = 3r$ $\quad r_Z = 2r$

$g_C = \frac{GM_C}{r_C^2}$ $\quad g_Z = \frac{GM_Z}{r_Z^2}$

$g_C = 1\ ms^{-2}$ $\quad g_Z = \frac{G(m)}{(2r)^2}$

ie. $\frac{G(3m)}{(3r)^2} = 1$ $\quad g_Z = \frac{GM}{4r^2}$

$\frac{GM}{3r^2} = 1$ $\quad \therefore g_Z = \frac{\left(\frac{GM}{4r^2}\right)}{\left(\frac{GM}{3r^2}\right)} \times 1$

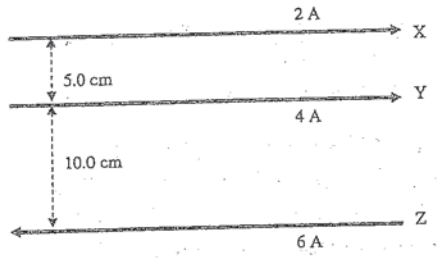
$\therefore g_Z = 0.75\ ms^{-2}$

Criteria	Mark
Calculates correct answer, with correct unit	2
Makes a single algebraic error, with correct unit	1

Marks

Question 28 (3 marks)

Three long, straight, parallel wires, X, Y and Z are 5.0 cm and 10.0 cm apart respectively and carry currents of 2A, 4A and 6A. The currents in wires X and Y are in the opposite direction to the current in wire Z.



Calculate the magnitude AND direction of the force per unit length on wire Y, due to the other two wires.

F/l = kI_1I_2/d F/l on wire Y = F_x upwards + F_z upwards
$= 2.0\times10^{-7}(2\times4/0.05 + 4\times6/0.1)$

F/l = 8.0×10^{-5} Nm^{-1} towards the top of the page (towards wire X)

OR up the page

3 marks awarded for correct answer including units Nm^{-1} and direction (not just up/upward)

2 marks awarded if a single error
1 mark awarded - 2 errors/omissions

Question 29 (4 marks)

The Large Hadron Collider sends beams of protons around the 27km long circular tunnel 11 000 times each second.

a) How fast are the protons travelling? 1

$v = \frac{\Delta r}{\Delta t} = \frac{27000}{1/11000} = 2.97\times10^8\ ms^{-1}$

b) What would an observer outside the Large Hadron Collider determine the mass of the proton to be whilst travelling at this speed? 3

$v = 2.97\times10^8\ ms^{-1}$
$m_0 = 1.673\times10^{-27}\ kg$

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

$m_v = \frac{1.673\times10^{-27}}{\sqrt{\left(1-\frac{(2.97\times10^8)^2}{(3\times10^8)^2}\right)}}$

$= 1.19\times10^{-26}\ kg$

1 error/omission = 2 mks
2 errors/omission = 1 mk.

Question 30 (3 marks)

The impact of the development of transformers on society has been enormous. Electrical energy from coal fired power stations is distributed to homes and industries at great distances from its point of generation using transformers. 3

Transformers are also a point of energy losses. Explain how these energy losses occur in transformers and how they can be reduced.

there must be linked for 2 mks.

Expanding & contracting magnetic fields result in flux cutting the core ⇒ eddy currents being induced resulting in energy loss as heat. Laminating the core minimizes eddy currents

One mark only

Cooling transformers increases their efficiency.
One method (at least) of cooling must be adequately described
OR
Core laminations made of ferrite with reason.

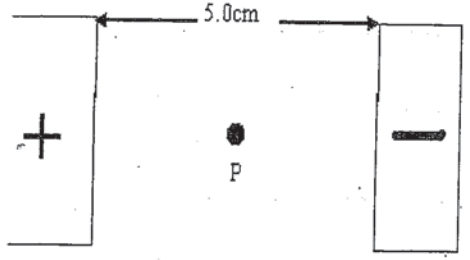
Sample answer

Transformers loose energy in the form of heat and sound. The heat and sound is generated by eddy currents induced in the soft iron core of the transformer. The energy losses are reduced by decreasing the size of the eddy currents induced during the transformation of the voltage. To reduce the size of the eddy currents induced the soft iron core is laminated – thin sheets of soft iron are sandwiched together with material which keeps the sheets slightly apart. This makes the metallic area available for the eddy current to be much smaller. The material used to make the soft iron core could be made from a different material, such as ferrite, which has the same magnetic enhancing properties of the soft iron, but does not allow such large eddy current to develop.
Thus the use of laminated ferrite for the core of the transformer reduces the size of the induced eddy currents and hence reduces energy losses in the transformer.

Marks

Question 31 (4 marks)

Two parallel plates with a potential difference of 10 000V are placed at a distance of 5.00 cm apart.



a) Draw the electric field between the TWO plates. Straight parallel equally spaced lines all the way from +ve to -ve with arrowheads (1)

b) A small test particle of mass 1.0×10^{-20} kg is given a positive charge of 3.2×10^{-10}C and placed at the point P, midway between the two plates. 3

What would be the acceleration (magnitude and direction) of the test particle?

$F = qE$ and $E = \frac{V}{d}$, so $F = \frac{qV}{d} = \frac{-3.2\times10^{-10}C \times 10000V}{0.05m} = 6.4\times10^{-5}N$ (to the right)

2 marks

$F = ma$, so $a = \frac{F}{m} = \frac{6.4\times10^{-5}N}{1.0\times10^{-20}kg} = 6.4\times10^{15}ms^{-2}$ to the right or negative plate

magnitude, units & direction 1 mark

8 → 6
7 → 5
6 → 4
5 → 3
4 → 3
3 → 2
2 → 2
1 → 1

Question 32 (6 marks)
Outcomes Assessed: H1, H2
Targeted Performance Bands: 3-6

Criteria	Marks
all relevant • Describes experimental results of both blackbody radiation and photoelectric effect AND • Relates results to inadequacies in current(classical/wave) model of light AND and describes inadequacies • Explains quantum theory as related to the model of light AND • Clear and concise linked statements needed	6
• Describes all relevant aspects of experimental results of both blackbody radiation and photoelectric effect AND • Relates results to inadequacies in current(classical/wave) model of light AND and describes inadequacies • Explains quantum theory as related to the model of light	5
• Describes some aspects of experimental results of blackbody radiation and photoelectric effect AND • Relates results to inadequacies in current(classical/wave) model of light AND/OR • Describes some aspects of the quantum theory as related to the model of light	3-4
• Describe some aspects of the experiments/results/explanation/theory proposed	2
• Identifies an aspect of the experiments/results/explanation/theory proposed	1

Sample answer

A blackbody emits electromagnetic radiation across a range of wavelengths, peaking in intensity at a wavelength related to the temperature of the black body. (As temperature increases, dominant wavelength decreases) Classical physics (wave model of emr/light) predicted that the intensity would increase for decreasing wavelength without limit. This violated the Law of Conservation of Energy (Ultraviolet Catastrophe) Blackbody radiation results required a new explanation. Planck proposed the radiation(energy/emr) was being emitted in packages of energy (quanta). The smallest amount of energy (photon) could be calculated using Planck's constant(h), i.e. E=hf. It was the start of the Quantum Theory. ($E \propto f$)
The Photoelectric Effect occurs when electrons are dislodged from metal surfaces by emr/light/UV. Experiments measured the energy of the photoelectrons emitted, which only increased as the frequency of the light is increased, as opposed to the intensity. A threshold frequency of the light must be achieved before photoelectrons are emitted. An ↑ in intensity only gave more photocurrent if f above f_o.
This contradicted the prediction from the classical (wave) model of light.
Einstein's explanation of the Photoelectric Effect drew upon Planck's quanta explanation of blackbody radiation, and verified the quantum nature of electromagnetic radiation (including light). The light (emr) was absorbed as a package (quanta/photon) , i.e. either wholly or not at all.
Energy of the photon over the threshold frequency was carried off by the photoelectron in the form of kinetic energy (speed).

Many students did not: say what the classical theory was
e.g. Light is a continuous wave.

say that a black body curve represents emission at a particular temperature

Astrophysics 2011

a) (i) apparent magnitude is a measure of the brightness of a star as seen from Earth, with the naked eye.
absolute magnitude is a measure of the brightness of a star if it was observed from a distance of 10 parsecs.

2 correct = 2 mks
1 " = 1 mk.

(ii) $\frac{I_A}{I_B} = 30 = 100^{\left(\frac{m-3.2}{5}\right)}$

$\log 30 = \log 100^{\left(\frac{m-3.2}{5}\right)}$

$= \left(\frac{m-3.2}{5}\right) \log 100$

$1.477 = \left(\frac{m-3.2}{5}\right) \times 2$

$m - 3.2 = \frac{1.477 \times 5}{2}$

$m = 3.2 + 3.69$

$= 6.89$

Marking scheme:

Substitutes correctly, calculates correctly	3 mk	eg. 6.9.
" " , but one error	2 "	
" " , but multiple errors	1	eg. 4.5
" incorrectly, no further errors	2	eg −0.49, 10.6, 3.5.7, 3.54.
" " , then one error	1	eg 9.5
" " , multiple errors	0	
Substitutes correctly	1	

b) (i) N.B. "adaptive optics" is used to counteract seeing effect from atmosphere.
Active optics are used to counteract change in shape of mirror due to gravity, heat, etc.
answer needed to contain, at least,
* fast/powerful computer
* deformable mirror
* rapid calculations, ≈ 1000/sec
* fast feedback
* Laser, or reference star
* beam splitter, or wave front sensor.

5-6 points = 4 mks.
3-4 " = 3 "
2 " = 2 "
1 point = 1 mk.

c) (i) Neutron star, black hole 1 mk.

(ii) * Average star uses PP chain to produce He in core
* Massive " " CNO cycle " " " " "
* Red giant fuses He in core to produce elements > He.
* Massive star fusions produce elements up to Fe
* Planetary nebula can produce fusion reactions
* Supernova produces elements > Fe

5-6 points = 3 mks.
3-4 " = 2 "
1-2 " = 1 "

d) (i) $p = \frac{1}{d}$

$p = \frac{1}{220} = 0.0045$ arcsec. 1 mk

N.B. Correct units were necessary.
Leaving answer as $\frac{1}{220}$ was not good enough.

(ii) Must be made from space
AND
identifies limitations
AND
outlines reasons for limitations
} all 3 for 2 mks.

Incomplete answer = 1 mk.

e) Note: all the stars in a cluster form around the same time. Some stars are bigger than others, and so have shorter lives on the M.S. It is not correct to look at the HR diagram of a cluster, and say that some stars are older than others.

1 * Must state that cluster A is older
AND
2 * More massive stars in A have moved off the M.S.
AND
3 * Larger stars on MS have shorter lives because they burn fuel faster
AND
4 * Larger stars are now red giants and do not fuse H in the core

Pt 1 and any 2 = 3 mks.
Pt 1 and another = 2 mks
Any 1 point = 1 mk

f) Binary stars: define
Can find: mass of system, mass of individual stars, support mass-luminosity, high increase in fuel use with mass, high mass → shorter time on M.S., distance between binary pair, speed of rotation around centre.
intrinsic, extrinsic
Variable stars: define ← periodic, non-periodic.
Can find: distance to stars in other galaxies, supports period-luminosity relationship, can estimate absolute magnitude
8 possible.

Justify: this all adds to our overall knowledge, and only way to determine mass.

Justify + 10-13 points = 6 mks. ; No justify = 4
" + 8-9 " = 5 " ; " = 3
" + 6-7 " = 4 " ; " = 2
" + 4-5 " = 3 " ; " = 1
" + 2-3 " = 2 "
" + 1 " = 1 "