Student number ……..

Class ……..

Teacher ……..

Cheltenham Girls
High School

2010
Higher School Certificate
Mid-course examination

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 2 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data-sheet and formulae sheets are provided at the back of this paper
- Write your Student Number and Class or teacher's name at the top of each page you write on

Total marks – 66

Pages 2 – 12
This exam has two parts, Part A and Part B

Part A – 15 marks

- Attempt Questions 1 – 15
- Allow about 25 minutes for this part

Part B – 51 marks

- Attempt questions 16 – 25

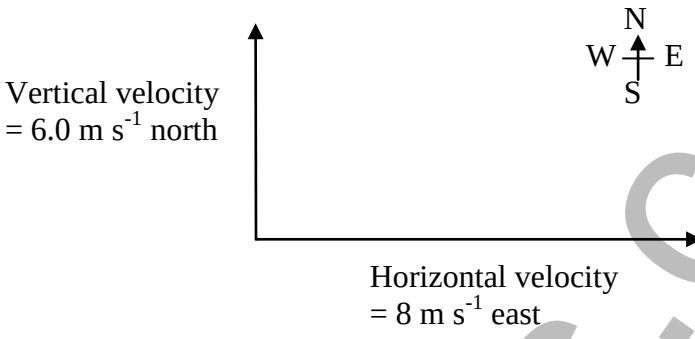
Allow about 1 hour and 35 minutes for this part

Part A Multiple Choice questions - 15 marks

Attempt all questions 1 to 15. Allow about 25 minutes to complete this Part.
Select the alternative A, B, C or D, that best answers the question and indicate your choice by clearly marking your answer in the appropriate place on the Multiple Choice Answer Sheet provided.

---

1. The horizontal velocity and vertical velocity of a projectile were measured. They are represented by the following vectors.



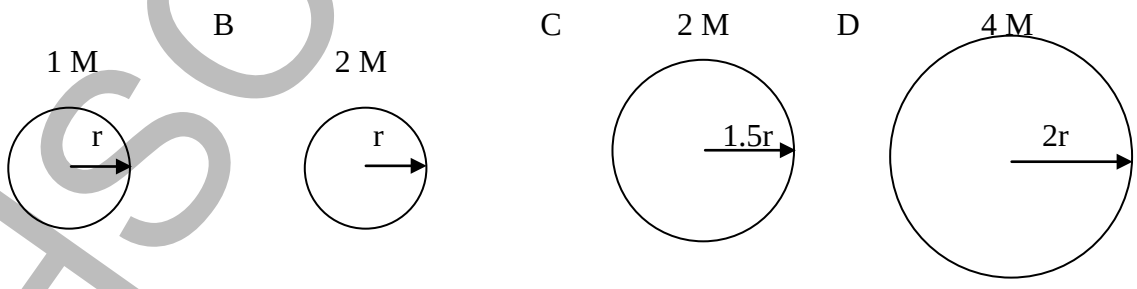
The actual velocity of the projectile is

(A) 7 m s^{-1} N36.9°E
(B) 7 m s^{-1} N53.1°E
(C) 10 m s^{-1} N36.9°E
(D) 10 m s^{-1} N53.1°E

2. Which of the following factors does NOT affect the escape velocity of an object from Earth?

(A) The mass of the object.
(B) The mass of the Earth
(C) The radius of the Earth
(D) The gravitational constant (G).

3. The following diagrams represent planets of different size and mass, as indicated.



Which of the planets would have the greatest acceleration due to gravity at its surface?

(A) Planet A
(B) Planet B
(C) Planet C
(D) Planet D

4. Refer to the following information about a group of satellites in orbit around a particular star.

Satellite	Period (units)	Distance to star (units)
Alpha	1	2
Beta	x	3.41
Gamma	4.23	5.23

The value of x is:
(A) 1.71
(B) 2.23
(C) 2.41
(D) 2.91

5. A ball is thrown into the air, leaving at an angle of 60^o to the horizontal at 10.0 m s^{-1}. The maximum height reached by the ball is

(A) 0.44 m
(B) 1.28 m
(C) 3.86 m
(D) 5.20 m

6. On a calm day, high on a cliff overlooking the ocean, a girl threw a stone horizontally at 6.55 ms $^{-1}$ over the edge of the cliff. She then measured the time it took the stone to hit the water below and found it took 3.03 seconds.
What is the height above the water from which the stone was projected?

(A) 19.65 m
(B) 29.69 m
(C) 44.99 m
(D) 64.83 m

7. The Michelson-Morley experiment was unsuccessful in proving the existence of the ether because:

(A) the apparatus was not sensitive enough.
(B) length contraction in the arm perpendicular to the "ether wind" occurred.
(C) the speed of light is constant and is independent of the motion of the source or observer.
(D) the ether was "carried along" with the Earth.

8. A satellite is in a stable circular orbit around the earth. Another satellite in a stable circular orbit at a greater altitude must have
(A) a smaller speed and a shorter period.
(B) a smaller speed and a longer period.
(C) a greater speed and a shorter period.
(D) a greater speed and a longer period.

9. Europa, a moon of Jupiter, has an orbital diameter of 1.34 x 10^9m, and a period of 3.55 days. What is the mass of Jupiter?

(A) 1.51 x 10^{27} kg
(B) 1.83 x 10^{27} kg
(C) 1.89 x 10^{27} kg
(D) 1.51 x 10^{28} kg

10. A spaceship takes a nonstop journey to a planet and returns in 10 hours according to a clock on the spaceship. Assume the speed of the spaceship is a constant 0.80c. How much time has elapsed according to an observer on the Earth?

(A) 6 hours
(B) 17 hours
(C) 22 hours
(D) 50 hours

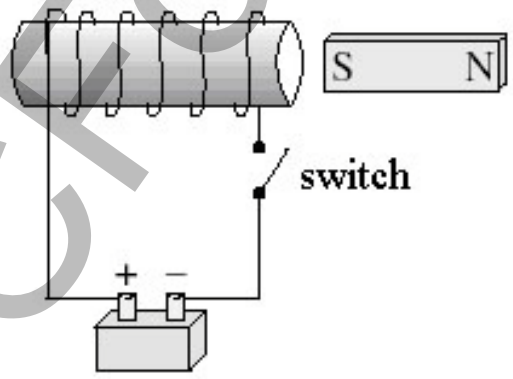
11. A thin copper rod 1.0 m long has a mass of 0.05 kg and is in a magnetic field of 0.10 T. What minimum current in the rod is needed in order for the magnetic force to cancel the weight of the rod?

(A) 1.2 A
(B) 2.5 A
(C) 4.9 A
(D) 9.8 A

12. The maximum torque on a current carrying loop occurs when the angle between the loop's plane and the magnetic field vector is:-

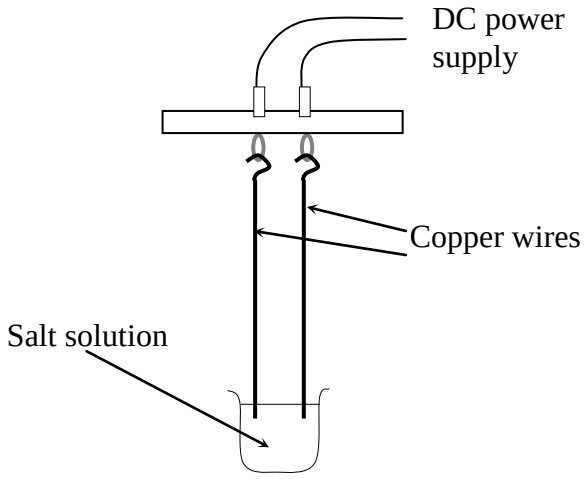
(A) 0^o
(B) 45^o
(C) 90^o
(D) 180^o

13. A bar magnet is at rest, next to a fixed coil. When the switch is closed, the bar magnet will move:-



(A) to the left.
(B) to the right.
(C) up the page.
(D) down the page.

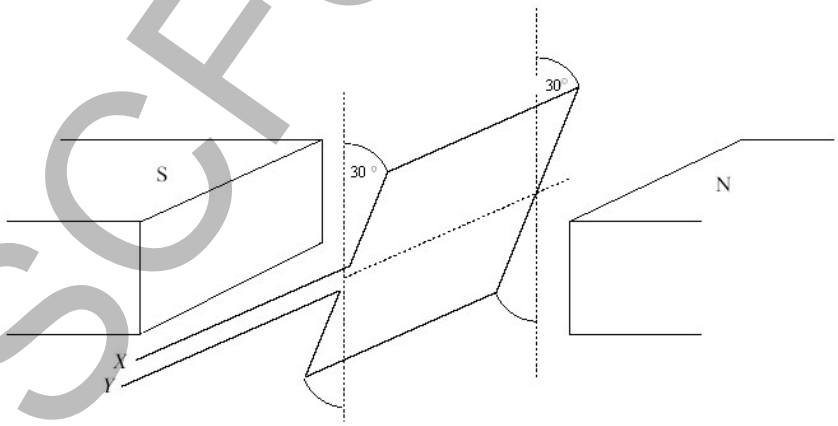
14. A student is conducting an investigation on the magnetic forces between current carrying wires. They have taken two equal, straight lengths of copper wire and suspended them from metal loops attached to a DC power supply, as shown in the diagram below:



When the power was switched on the student observed that the wires were weakly repelled from each other. The student then decided to try to modify the set-up so that the wires will now be attracted to each other and also to attempt to increase the size of the force acting. Which of the following combinations of changes could the student make to the set-up to be sure they will achieve the desired result?

(A) Increase the length of the wires and reverse the connections to the DC power supply.
(B) Increase the length of the wires and increase the size of the current flowing.
(C) Reverse the direction of the current in one wire and use longer wires.
(D) Increase the current in the wires and reverse the connections to the DC power supply.

15. A coil of wire that is free to spin is placed between two magnets as shown in the diagram below.



X is connected to the positive terminal of a power supply, and Y is connected to the negative terminal. The coil is set in the position shown and viewed from the front near X and Y. Which of the following will occur when the power supply is turned on?

(A) The coil will rotate continuously in an anticlockwise direction.
(B) The coil will rotate continuously in a clockwise direction.
(C) The coil will rotate anticlockwise and stop 30° from where it started.
(D) The coil will rotate clockwise and stop 150° from where it started.

Part B Written Response questions - 51 marks

Attempt all Questions 16 to 25
Allow about 1 hour and 35 minutes to complete this Part.

Answer the questions in the space provided.

Show all relevant working in questions involving calculations.

Marks

Question 16 (3 marks)
NASA recently landed a space probe on an asteroid found between the orbits of Earth and Mars. The 600 kg space probe had a weight of 30 N when it landed on the asteroid.

(a) What would be the weight of this space probe on the surface of Earth? 1

.....

.....

(b) Before landing on the asteroid, the space probe was placed in an orbit with radius 30 km. The orbital period was 7.9×10^4 s. What was the mass of the asteroid? 2

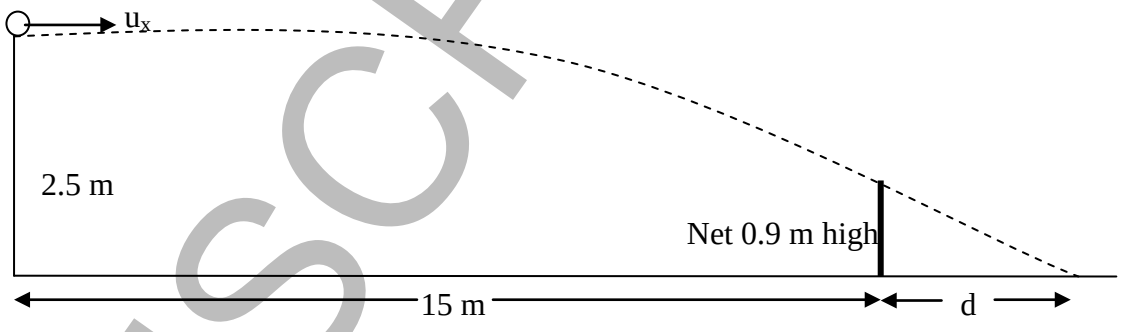
.....

.....

.....

.....

Question 17 (10 marks)
A tennis player aims to serve the ball horizontally when his racquet is 2.5 m above the ground. The distance from the player to the net is 15.0 m and the net is 0.9 m high.



If the ball is just clear the net,
(a) What is the time for the ball to reach the top of the net? 2

.....

.....

.....

.....

.....

Question 17 continues on page 7

(b) What is the minimum speed (u_x) with which the ball must leave the racquet? 2

.....

.....

.....

.....

.....

(c) What is the total time for which the ball is in the air from the time that it leaves the racquet until it hits the ground? 2

.....

.....

.....

.....

.....

(d) How far beyond the net does the ball land (distance d)? 2

.....

.....

.....

.....

.....

(e) What is the final velocity of the ball? 2

.....

.....

.....

.....

.....

Question 18 (8 marks)

(a) Explain the changes in momentum when a satellite fires its propulsion system. 3

.....

.....

.....

.....

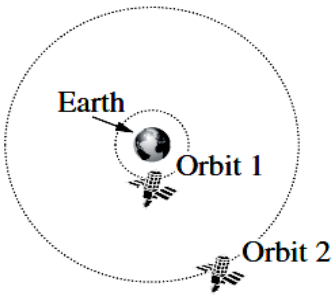
.....

.....

Question 18 continues on page 7

Question 18 (continued)

(b) A satellite is propelled from Orbit 1 to Orbit 2 as shown in the diagram.



Marks

Orbit 2 has a radius of 27000 km. What is the satellite's speed in this orbit? 3

.....

.....

.....

.....

.....

.....

(c) The radius of Orbit 2 is four times that of Orbit 1. What is the ratio of the new orbital period to the original period? 2

.....

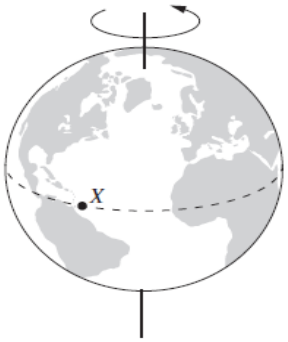
.....

.....

.....

Question 19 (4 marks)

The diagram shows the position X on the Earth's surface from which a satellite is to be launched into a geostationary orbit.



(a) On the diagram, draw an arrow to show the direction of launch from X, and justify your choice. 1

.....

.....

.....

Question 19 continues on page 7

Marks

(b) Given that the radius of the Earth is 6.38×10^6 m, calculate the height of the satellite above the Earth's surface. 3

.....

.....

.....

.....

.....

.....

.....

.....

Question 20 (7 marks)

(a) Discuss how our understanding of time has been influenced by the discovery of the constancy of the speed of light? 2

.....

.....

.....

.....

(b) A piece of radioactive material of mass 2.5 kilograms undergoes radioactive decay. How much energy is released if 10 grams of this mass are converted to energy during the decay process? 2

.....

.....

.....

.....

(c) A mass is moving in an inertial frame of reference at a velocity $\boldsymbol{v}$ relative to a stationary observer. The observer measures an apparent mass increase of 0.37%.

Calculate the value of $\boldsymbol{v}$ in m s^{-1}. 3

.....

.....

.....

.....

.....

.....

.....

.....

Question 21 (3 marks)

A student is investigating inertial and non-inertial frames of reference. The student carries out a series of activities on a boat floating on a large, calm lake. The boat remained level during these activities.

Each activity and the student's observed results are recorded in the table.

Activity	Observation
Dropped a ball from a set height	Ball fell vertically with increasing velocity
Rolled a ball from one side of the boat to the other	Ball rolled across the floor with a constant velocity
Rolled a ball from the back of the boat towards the front of the boat	Ball rolled across the floor with a constant velocity

Marks

Justify the student's conclusion that: "The boat can be regarded as an inertial frame of reference". 3

.....

.....

.....

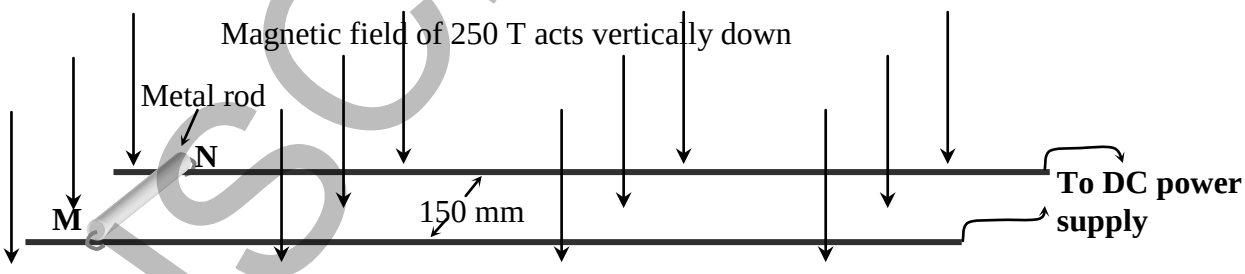
.....

.....

.....

Question 22 (2 marks)

In a demonstration device a light metal rod, **M-N**, sits loosely attached with hooks on two parallel metal rails, a distance 150 mm apart. A uniform magnetic field of 250 T acts vertically down as shown. When a DC power supply attached to the ends of the metal rails is switched on, a current of 8.40 A flows through the rails and rod. This results in a magnetic force acting on the rod and it is observed to move to the right, sliding easily along the horizontal rails.



State the direction of current flow through the metal rod and calculate the magnetic force that acts on the rod when the power is first switched on 2

.....

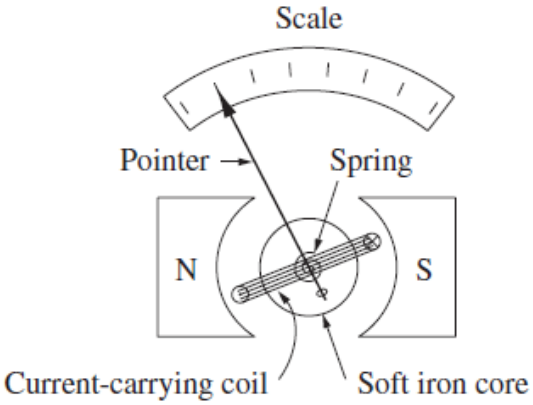
.....

.....

.....

Question 23 (3 marks)

The diagram shows the structure of a typical galvanometer.



Marks

Describe how the galvanometer operates as an application of the motor effect. 3

.....

.....

.....

.....

.....

.....

.....

.....

.....

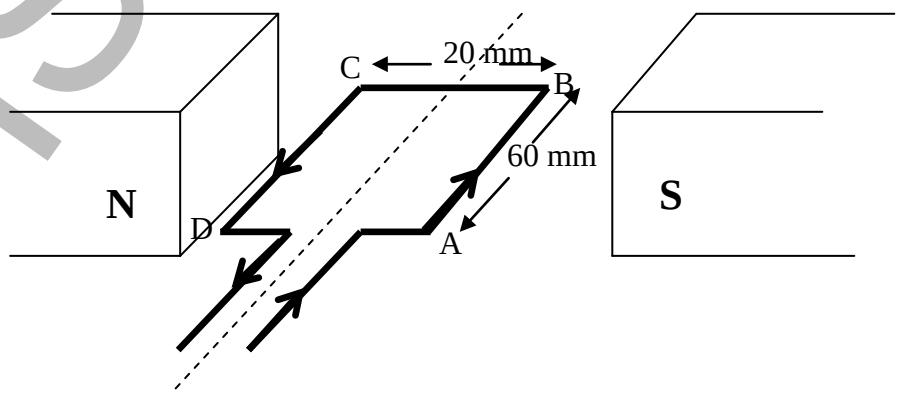
.....

.....

.....

Question 24 (7 marks)

A rectangular rotor coil of 100 turns is positioned between the poles of two magnets as shown below. The plane of the coil lies parallel with the direction of the field. The side AB measures 60 mm while side BC measures 20 mm. The magnetic field strength is 0.2 T and the current in the coil is 5 A.



Question 24 continues on page 12

(a) In what direction will the coil begin to rotate when viewed from A? 1

.....

.....

(b) To ensure the coil rotates continuously, explain what must be done to the current in the coil. 2

.....

.....

.....

.....

(c) The axle is to be attached to a fan which spins at a regular rate. Discuss the need for a commutator and brushes, and explain how they allow the coil to continue spinning. 2

.....

.....

.....

.....

(d) Determine the torque when the coil is: 2

(i) parallel to the field

.....

.....

(ii) Perpendicular to the field

.....

.....

Question 25 (4 marks)

Headphones contain small loud speakers. Using a labelled diagram describe how a loudspeaker produces sound from electrical energy. 4

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

End of Paper

DATA SHEET

Charge on electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	340 m s^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Speed of light, c	3.00×10^8 m s^{-1}
Magnetic force constant, $\left(k \equiv \frac{\mu_0}{2\pi}\right)$	2.0×10^{-7} N A^{-2}
Universal gravitational constant, G	6.67×10^{-11} N m^2 kg^{-2}
Mass of Earth	6.0×10^{24} kg
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	1.097×10^7 m^{-1}
Atomic mass unit, u	1.661×10^{-27} kg 931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, ρ	1.00×10^3 kg m^{-3}
Specific heat capacity of water	4.18×10^3 J kg^{-1} K^{-1}

FORMULAE SHEET

$$v = f\lambda$$

$$I \propto \frac{1}{d^2}$$

$$\frac{v_1}{v_2} = \frac{\sin i}{\sin r}$$

$$E = \frac{F}{q}$$

$$R = \frac{V}{I}$$

$$P = VI$$

$$\text{Energy} = VIt$$

$$v_{av} = \frac{\Delta r}{\Delta t}$$

$$a_{av} = \frac{\Delta v}{\Delta t} \text{ therefore } a_{av} = \frac{v-u}{t}$$

$$\Sigma F = ma$$

$$F = \frac{mv^2}{r}$$

$$E_k = \frac{1}{2}mv^2$$

$$W = Fs$$

$$p = mv$$

$$\text{Impulse} = Ft$$

$$E_p = -G\frac{m_1 m_2}{r}$$

$$F = mg$$

$$v_x^2 = u_x^2$$

$$v = u + at$$

$$v_y^2 = u_y^2 + 2a_y\Delta y$$

$$\Delta x = u_x t$$

$$\Delta y = u_y t + \frac{1}{2}a_y t^2$$

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

$$F = \frac{Gm_1 m_2}{d^2}$$

$$E = mc^2$$

$$l_v = l_0\sqrt{1-\frac{v^2}{c^2}}$$

$$t_v = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$m_v = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

FORMULAE SHEET

$$\frac{F}{l} = k\frac{I_1 I_2}{d}$$

$$F = BIl\sin\theta$$

$$\tau = Fd$$

$$\tau = nBIA\cos\theta$$

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

$$F = qvB\sin\theta$$

$$E = \frac{V}{d}$$

$$E = hf$$

$$c = f\lambda$$

$$Z = \rho v$$

$$\frac{I_r}{I_0} = \frac{\left[Z_2 - Z_1\right]^2}{\left[Z_2 + Z_1\right]^2}$$

$$d = \frac{1}{p}$$

$$M = m - 5\log\left(\frac{d}{10}\right)$$

$$\frac{I_A}{I_B} = 100^{(m_B - m_A)/5}$$

$$m_1 + m_2 = \frac{4\pi^2 r^3}{GT^2}$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\lambda = \frac{h}{mv}$$

$$A_0 = \frac{V_{\text{out}}}{V_{\text{in}}}$$

$$\frac{V_{\text{out}}}{V_{\text{in}}} = -\frac{R_{\text{f}}}{R_{\text{i}}}$$

Remove and hand this Multiple Choice Answer Sheet in separately.

Cheltenham Girls High School

Year 12 Mid-course examination

Student name ……

Student number ……

Class …… Teacher ……

Course ……

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

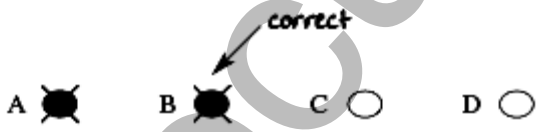
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

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

A ● B ⊗ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word correct and drawing an arrow as follows.



1	A O	B O	C O	D O
2	A O	B O	C O	D O
3	A O	B O	C O	D O
4	A O	B O	C O	D O
5	A O	B O	C O	D O
6	A O	B O	C O	D O
7	A O	B O	C O	D O
8	A O	B O	C O	D O
9	A O	B O	C O	D O
10	A O	B O	C O	D O
11	A O	B O	C O	D O
12	A O	B O	C O	D O
13	A O	B O	C O	D O
14	A O	B O	C O	D O
15	A O	B O	C O	D O

Cheltenham Girls High School – 2 Unit Physics
H.S.C. Mid course exam 2010 – MARKING GUIDLINES

Part A (15 marks)

Question	Correct response
1	D
2	A
3	B
4	B
5	C
6	C
7	C
8	B
9	D
10	B
11	B
12	C
13	B
14	C
15	C

Part B (51 marks)

Question		Marking Criteria	Marks
16	a	• Correctly calculate the weight	1
		Sample answer: $w = mg = 600 \text{ kg} \times 9.8 \text{ m/s}^2 = 5880 \text{ N}$	
	b	• Correct method and result	2
		• Correct method only	1
		Sample answer: $R^3/T^2 = GM_E/4\pi^2$ $M = 4\pi^2 R^3/G T^2 = 2.56 \times 10^{15} \text{ kg}$	
17	a	• Correct method and result	2
		• Correct method only	1
		Sample answer: $\Delta y = u_y t + \frac{1}{2} a_y t^2$ $t = 0.57 \text{ s}$	
	b	• Correct method and result	2
		• Correct method only	1
		$u_x = \Delta x/t$ $u_x = 26.32 \text{ m/s}$	
	c	• Correct method and result	2
		• Correct method only	1
		Sample answer $\Delta x = u_y t + \frac{1}{2} a_y t^2$ $t = 0.71 \text{ s}$	
	d	• Correct method and result	2
		• Correct method only	1
		Sample answer: Total horizontal distance travel = $u_y t = 26.32 \times 0.71 = 18.69 \text{ m}$ $d = 18.69 - 15 = 3.69 \text{ m}$	

	e	• Correct method and result	**2**
		• Correct method only	1
		Sample answer: Final velocity = $(v_x^2 + v_y^2)^{½} = (26.32^2 + 6.96^2)^{½} = 27.20$ m/s	
18	**a**	• Identifies the changes in momentum of the satellite and of the exhaust gases AND EITHER • Indicates that these momentum changes are equal and opposite (cancel each other) OR • Indicates that the total momentum of the satellite/gases system is conserved	**3**
		Any TWO of the following: • Identifies the changes in momentum of the satellite OR the exhaust gases • Identifies change in direction • States that total momentum is conserved	**2**
		• Identifies one change in momentum OR • States that total momentum is conserved	1
		Sample answer: Upon firing, the forward momentum of the satellite increases by an amount equal to the momentum in the opposite direction (relative to the satellite) of the exhaust gases. However the total momentum of the (closed) system containing the satellite and exhaust gases remains constant.	
	b	• Substitutes correctly to determine the new speed	**3**
		• Equates TWO appropriate equations AND EITHER • Makes an error in rearranging the equations OR • Makes an error in substitution	2
		• Chooses one correct formula only and attempts to find the speed	1
		Sample answer: $V = 3.8 \times 10^3$ m/s	
	c	• Substitutes correctly to calculate ratio	**2**
		• Uses formula correctly but makes an error in substitution	1
		Sample answer: T^2 is proportional to R^3 $(T_1/T_2)^2 = (R_1/R_2)^3$ substitute $R_2 = 4 \times R_1$ $T_2 = 8 \times T_1$	
19	**a**	• Draw arrow towards East from X • Provides an appropriate justification	**1**
		Sample answer: The Earth rotates from the west to the east on its axis per day, so if a satellite launches from west to east, it will gain the velocity of the rotation of the Earth.	
	b	Identifies correct formula • Correctly substitutes G, M and T • Subtracts the earths radius to calculate value r	**3**

		• Any two of the above OR • Recalls correct value for satellite radius and subtracts radius of Earth	2
		• Any one of the above OR • Recalls correct value of altitude	1
		Sample answer: T = 24 hours = 86400 s $R^3 / T^2 = GM_E / 4\pi^2$ $R^3 = GM_E T^2 / 4\pi^2$ $R^3 = (6.67 \times 10^{-11} \times 5.97 \times 10^{24} \times 86400^2) / 4\pi^2$ $R = 4.22 \times 10^7$ m Height above Earth surface = $4.22 \times 10^7 - 6.38 \times 10^6$ m = 3.58×10^7 m	
20	**a**	• Refers to c as a constant, so time is relative to observer • Refers to c as a constant, so time can be used to define length OR • States an example of time dilation of a rapidly moving object	**2**
		Refers to c as a constant, so time is relevant to observer OR Refers to c as a constant, so that time can be used to define length OR states an example of time dilation of a rapidly moving object	1
	b	• Identifies correct formula AND correctly substitutes	**2**
		• Identifies correct formula	1
		Sample answer: $E = Mc^2 = 10$ g x $(3 \times 10^8$ m/s$)^2 = 1 \times 10^{-2}$kg x $(3 \times 10^8$ m/s$)^2 = 9 \times 10^{14}$ J	
	c	• Identifies correct formula and correctly substitutes • Manipulates correct formula to extract v	**3**
		• Identifies correct formula and correctly substitutes	2
		• Identifies correct formula	1
		Sample answer: $M_v = M_o/(1 - v^2/c^2)^{1/2}$ If $M_v = 1.0037$ Mo $1.0037M_o = M_o/(1 - v^2/c^2)^{1/2}$ $1.0037 = 1/(1 - v^2/c^2)^{1/2}$ $v = 8.57 \times 10^{-2}$ c (OR 2.5737×10^7 ms^{-1})	
21		• Falling ball's acceleration due to gravitational force only • Balls moving horizontally do not exhibit acceleration • An inertial frame of reference is defined or described correctly	**3**
		• Any two of the above criteria	2
		• Any one of the above criteria	1
22		• State the direction of current flow correctly • Calculate the magnetic force correctly	**2**
		• State the direction of current flow correctly OR • Calculate the magnetic force correctly	1

		Sample answer: The current flows from N to M F = BIl = 0.25 T x 8.4 A x 0.15 m = 315 N to the right	
23		• Describes how the components interact to enable the meter to operate including reference to the motor effect	**3**
		• Correctly describes purpose of some components and origin of motor effect, but does not discuss radial field, constant torque, or linear scale	2
		• Describes function of only ONE component of galvanometer	1
		Sample answer: The galvanometer works because of the motor effect. The coil consists of many loops of wire and it is connected in series with the rest of the circuit so that when the current flows, the coil has a force due to the external magnetic field. The iron coil increases the magnitude of this force. The needle is rotated until the magnetic force acting on the coil is equalled by a counteracting balancing spring.	
24	**a**	• State the direction of the rotation of the coil	**1**
		Sample answer: The coil will rotate clockwise	
	b	• Explain what must be done to the current in the coil.	**2**
		• Describe what must be done to the current in the coil without explanation	1
		Sample answer: The current must be reversed each half cycle. If the current is not reversed, the coil will come to rest in the vertical plane	
	c	• Explain how a commutator and brushes allow the coil to continue spinning	**2**
		• Explain how a commutator OR • brushes allow the coil to continue spinning	1
		Sample answer: A commutator ensures constant direction torque by changing direction of current flow through the coil every 180^o. The brushes provide electrical contact between the external power supply and the split ring commutator.	
	d	• Calculate the torque correctly	**2**
		Sample answer: (i) τ = nBIACos θ =100 x 0.2 T x 5 A x 0.02 x 0.06 x Cos 0^o = 0.12 Nm (ii) τ = nBIACos θ =100 x 0.2 T x 5 A x 0.02 x 0.06 x Cos 90^o = 0	
25		• Electrical current creates a fluctuating magnetic field around a coil • This field interacts with a nearby magnet and the coil vibrates back and forth • The attached speaker cone vibrates too, and send sends compression waves into the air • With a correct labelled diagram	**4**
		• Any 3 of the above	3
		• Any 2 of the above	2
		• Any 1 of the above	1