⊛ SOLUTIONS

MID-HSC COURSE EXAMINATION

YR.12 2005

MARCH 2005

PHYSICS 2 UNIT

MULTIPLE CHOICE ANSWER SHEET

PART A

For each question (1 – 10) choose the best of the four possible answers and indicate your choice by marking the appropriate space below. Mark only ONE choice for each question, using a pencil. Do NOT use a ball-point or an ink pen. If you change your mind, completely erase your first mark.

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

⊛ Worked solutions to the multiple choice follow.

PART A

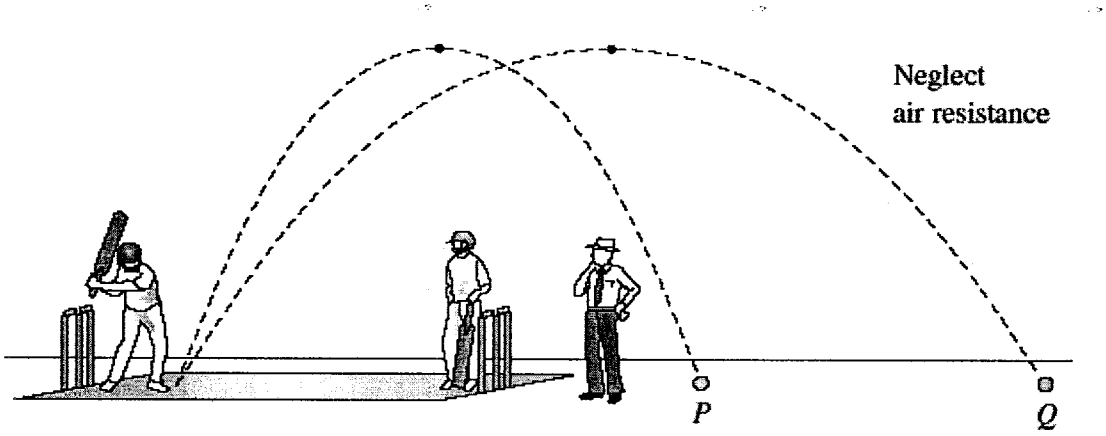
Total Marks (10)
Attempt all questions 1 to 10.
Allow 18 minutes for this part.

Questions 1 to 10 are worth One Mark Each.

For each question (1 – 10) choose the best of the four possible answers and indicate your choice by marking the appropriate space on the Answer Sheet provided. Mark only ONE choice for each question, using a pencil. Do NOT use a ball-point or an ink pen. If you change your mind, completely erase your first mark.

QUESTION 1

The picture below shows a game of cricket.



The picture shows two consecutive shots by the batsman. Both balls reach the same maximum height above the ground but ball *Q* travels twice as far as ball *P*.

Which of the following is DIFFERENT for balls *P* and *Q*?

(A) Gravitational acceleration

(B) Gravitational force

(C) Time of flight

(D) Initial velocity

QUESTION 2

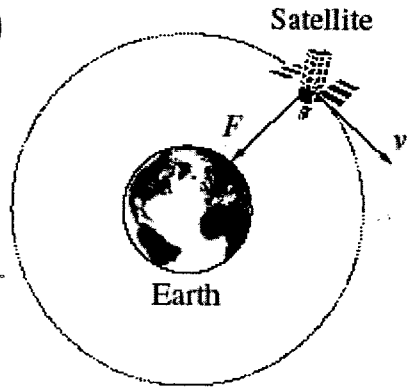
A satellite moves in uniform circular motion around Earth.
The following table shows the symbols used in the diagrams below.
These diagrams are NOT drawn to scale.

Key
F = Net force on satellite
v = Velocity of satellite

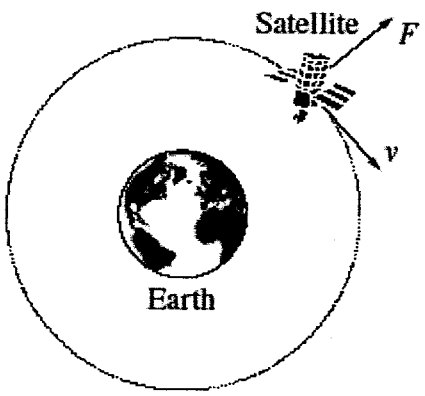
Which diagram shows the correct direction of F and v at the position indicated?

A

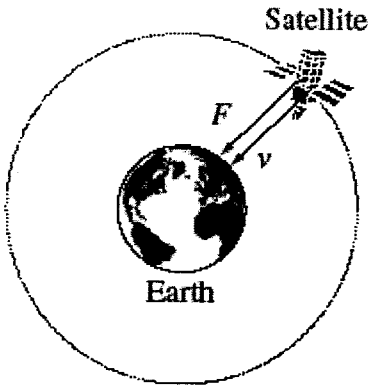
(A)



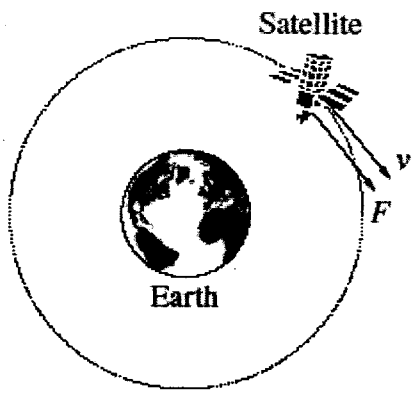
(B)



(C)



(D)



QUESTION 3

A man weighs 1000 N at the surface of the earth. With the aid of the information in the following table, estimate the man's weight on the surface of planet X.

PLANET	MASS (10^{24} kg)	RADIUS (km)
X	3.0	6400
Earth	6.0	6400

(A) 500 N

(B) 1000 N

(C) 2000 N

(D) 4000 N

A

$mg = \frac{GmM}{r^2}$

$g = \frac{GM}{r^2}$

$g \propto \frac{M}{r^2}$

$g_x \propto \frac{M_x}{r_x^2}$

$\propto \frac{\frac{1}{2}M_e}{r_e^2}$

$\propto \frac{1}{2}g_e$

$\therefore W_x = \frac{1}{2}W_E$

$= 500N$

QUESTION 4

An astronaut set out in a spaceship from Earth orbit to travel to a nearby star in our galaxy. The spaceship travelled at a constant speed of 0.95 *c*. When the spaceship reached the star the on-board clock showed the astronaut that the journey had taken 5 years.

An identical clock remained on Earth. What time in years had elapsed on this clock as seen by an observer who had remained on Earth with the clock?

(A) 16.0

A (B) 22.4

(C) 51.3

(D) 100.0

$t = \frac{t_o}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{5}{\sqrt{1 - \frac{(0.95c)^2}{c^2}}}$

$= 16.01$ yrs.

QUESTION 5

The most likely cause of the orbital decay of satellites in low Earth orbit is:

(A) Decrease in mass as fuel is used up

(B) Friction between the satellite and the solar wind

(C) Friction between the satellite and cosmic ray particles

D

(D) Friction between the satellite and the top of the Earth's atmosphere

QUESTION 6

A physicist builds a transformer to increase the 240 V AC mains electricity supply to 480 V AC. To do this, the number of turns of wire on the primary coil must be:

(A) The same as the number of turns of wire on the secondary coil

(B) Double the number of turns of wire on the secondary coil

C

(C) Less than the number of turns of wire on the secondary coil

(D) More than the number of turns of wire on the secondary coil

$$\frac{V_p}{V_s} = \frac{N_p}{N_s} = \frac{240}{480}$$

QUESTION 7

Of the following components, the one that is least likely to be used in an AC electric motor is:

(A) Slip rings

(B) Split ring commutator

B

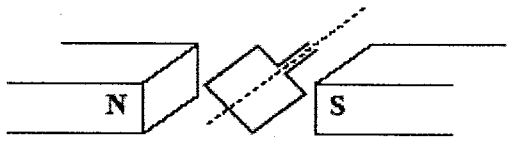
(C) Rotor

(D) Stator

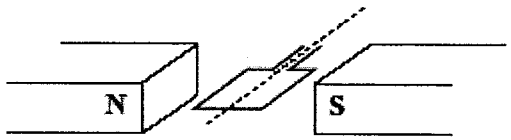
QUESTION 8

A coil of wire is in a uniform magnetic field between two magnets. The coil of wire is rotated about an axis. In which of the following diagrams is the magnetic flux through the coil greatest?

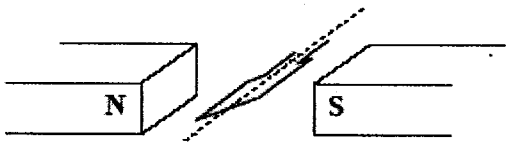
(A)



(B)

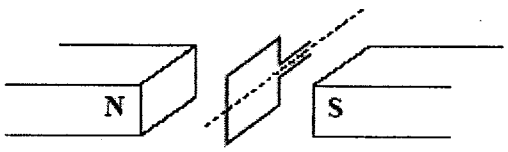


(C)



D

(D)

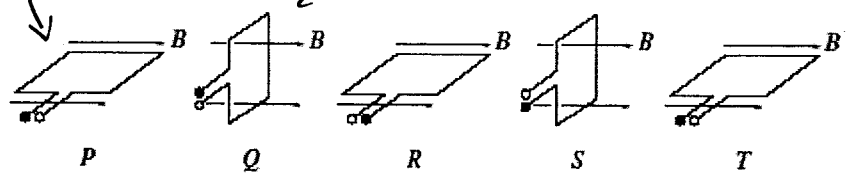


QUESTION 9

Max $\frac{\Delta\phi}{\Delta t}$ $\frac{\Delta\phi}{\Delta t} = 0$

The coil of an AC generator rotates at a constant rate in a magnetic field as shown.

Max $\mathcal{E}$ $\mathcal{E}=0$

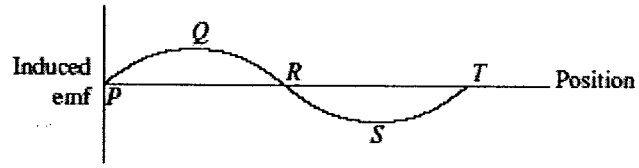


Which of the following diagrams represents the curve of induced emf against position?

$\mathcal{E} = -N\frac{\Delta\phi}{\Delta t}$

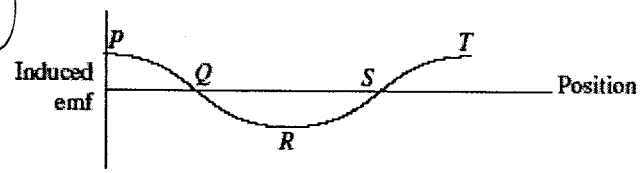
$\mathcal{E} \propto \frac{\Delta\phi}{\Delta t}$

(A)



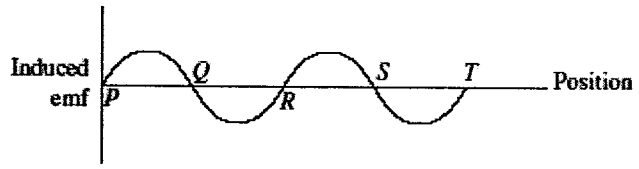
(B)

B

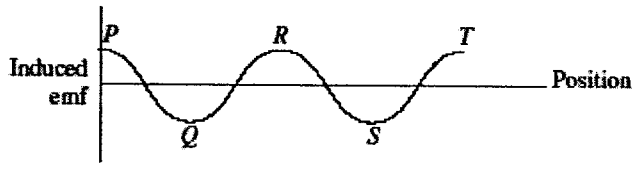


$\begin{cases} \mathcal{E} = \text{max at } P \\ \mathcal{E} = 0 \text{ at } Q \end{cases}$

(C)



(D)



QUESTION 10

Two straight metal rods, *P* and *Q*, have the same length. They are each pivoted at one end and rotated with the same orbital speed so that they sweep out horizontal circular paths as shown in diagrams *X* and *Y*. A constant current *I* is flowing along each rod, as shown.

In diagram *X*, a constant magnetic field is applied *at right angles to the plane* of the circular path. In diagram *Y*, a uniform magnetic field of the same magnitude is applied *in the plane* of the circular path.

$F = BIl\sin\theta$
$= BIl\sin 90^\circ$
$= BIl$

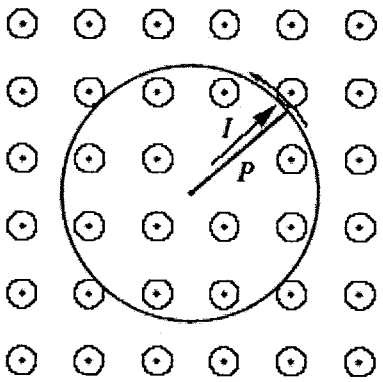


Diagram *X*

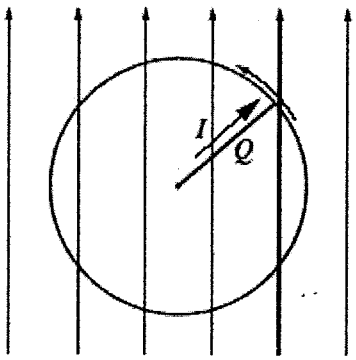


Diagram *Y*

$F = BIl\sin\theta$

Which of the following statements about the forces acting on rod *P* and rod *Q* is correct?

(A) The magnitude of the force on *P* is exactly the same as the magnitude of the force on *Q* at all times.

(B) The magnitude of the force on *P* is constant and the magnitude of the force on *Q* is zero.

C (C) The magnitude of the force on *P* is constant and the magnitude of the force on *Q* varies with time.

(D) The magnitude of the force on *P* varies with time and the magnitude of the force on *Q* is constant.

PART B

Total Marks (44)
Attempt all questions 11 to 20.
Allow 72 minutes for this part.

Questions 11 to 20 are FREE RESPONSE Questions.

For each question (11 – 20) write your answer in the appropriate space. You are advised to show your *full* working for all answers as marks may be awarded for relevant working.

QUESTION 11 (4 Marks) **Marks**

(a) Use the Law of Conservation of Momentum to explain how a space rocket such as the Space Shuttle lifts off the ground at launch.

Before Launch: momentum of rocket + fuel system = 0

∴ After Launch: momentum of rocket + fuel system = 0, by Law of Conservation of Momentum. (1) 2

So, since after launch the fuel has a net downward momentum ($M_{fuel} \cdot V_{fuel}$), the rocket must have an equal sized momentum ($M_{rocket} \cdot V_{rocket}$) in opposite direction (upwards), (1)
to ensure that the momentum of rocket + fuel system = 0.

(b) Explain why the acceleration of the Space Shuttle increases during launch and describe how this affects the forces experienced by the astronauts.

As fuel is burnt, mass of rocket decreases. Since thrust of the rocket motor is constant, the acceleration of rocket must increase, as mass decreases ($F=ma$). (1) 2

As acceleration of rocket increases, the force on the astronauts ($F=ma$) also increases. (1)

QUESTION 12 (5 Marks) **Marks**

Isaac Newton did much to improve our understanding of gravity.

(a) There are many natural satellites in our Solar System. The Earth moves in orbit around the Sun and the Moon is in orbit around the Earth to name just two examples. Briefly, discuss the importance of Newton's Law of Universal Gravitation in understanding and calculating the motion of such satellites. **2**

$F = G\frac{M_1M_2}{r^2}$ is very important because: ① It provides an accurate physical/mathematical model of how one object in the universe affects the other; ② It provides predictive power – we can use the model to calculate the motion of planets around the Sun and moons around planets very accurately; ③ This predictability allows us to engage in accurate voyages to the planets + moons.

(1) (1)

(b) Calculate the gravitational force of the Earth on the Moon, given that the mass of Earth is 5.98×10^{24} kg, mass of Moon is 7.35×10^{22} kg and distance from the Earth to the Moon is 3.844×10^{8} m. **1**

$F_{EM} = G\frac{M_E M_M}{r_{EM}^2} = \frac{6.67\times10^{-11}\times 5.98\times10^{24}\times 7.35\times10^{22}}{(3.844\times10^{8})^2}$

$= 1.98\times10^{20}$ N, attractive

(1)

(c) Identify an example of how gravity can be used to advantage by a space probe. **1**

Sling shot effect } or similar
Gravity Assisted Trajectories }

(1)

(d) A spaceship flies past the Earth parallel to its axis of rotation at a speed of 0.99c. Determine the diameter of the Earth from the north to south pole as seen by the pilot of the spaceship. The diameter of the Earth as seen by an observer stationary with respect to the Earth is 1.28×10^{7} m. **1**

$l = l_0\sqrt{1-\frac{v^2}{c^2}} = 1.28\times10^{7}\times\sqrt{1-\frac{(0.99c)^2}{c^2}}$

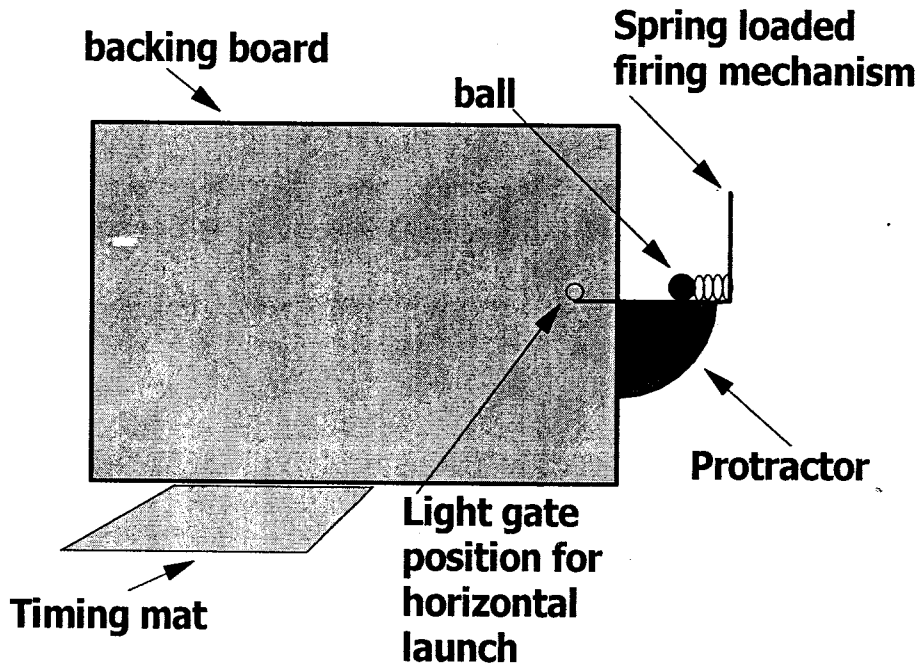
$= 1.8\times10^{6}$ m

(1)

Marks

QUESTION 13 (7 Marks)

A Physics student uses the apparatus shown below to measure some key parameters of projectile motion.



A steel ball was launched from a spring loaded firing mechanism. The launch platform could be arranged horizontally or at various angles θ to the horizontal. The height from which the ball is launched could also be adjusted. The initial velocity v_0 of the ball could be measured using a light gate held by a retort stand (not shown here) and slotted into position in the backing board. The time of flight could be measured using a light gate in combination with a timing mat. Both the light gate and timing mat were connected to the appropriate terminals of a data logger.

The following table contains all the data recorded by the student. The student took only one measurement of each variable. The range was measured by observing where the ball landed and measuring the distance with a ruler.

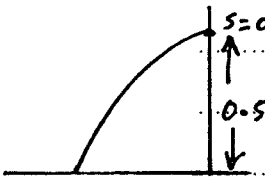
v_0 (m/s)	θ (degrees)	Height from which ball was launched (m)	Time of flight (s)	Range (m)
0.200	0^o	0.50	0.319	0.060
0.195	30^o	0.50	0.330	0.045
0.190	45^o	0.50	0.333	0.040
0.183	60^o	0.50	0.336	0.030

Questions appear on next page.

Marks

(a) For the case of horizontal launch, compare the experimentally obtained value of the time of flight with that which is expected from theory. **2**

From Theory: $s = ut + \frac{1}{2}at^2$, so vertically we have:



$-0.5 = 0 - \frac{1}{2}gt^2$ (1)

$\therefore t = 0.325$, which to 2 decimal places is same as experimental value of 0.319s. (1)

(b) For the case of $\theta = 30°$, compare the experimental value of the range with that which is expected from theory given the initial velocity, launch angle and time of flight as stated in the table. **1**

Theory: $R = V_0 \cos\theta \cdot t$ (½)

$= 0.195 \times \cos 30° \times 0.330$

$= 0.056$ m

$= 5.6$ cm

This theoretical value is 1.1 cm larger than the expt. value of 4.5 cm. (½)

(c) For the case of $\theta = 60°$, determine the magnitude of the vertical component of velocity at the instant the ball hits the timing mat. Use the values of the initial velocity, launch angle and time of flight as stated in the table. **1**

Vertically: From $v = u + at$, $v_y = V_0 \sin\theta - gt$ (1)

$\therefore v_y = 0.183 \times \sin 60° - 9.8 \times 0.336$

$= -3.13\ ms^{-1}$ Vertical Comp. of Velocity = 3.13 m/s down.

(d) State TWO changes to the method of this experiment that would improve the reliability of the experiment. **2**

① Take multiple readings of each measurement + take the average. (1)

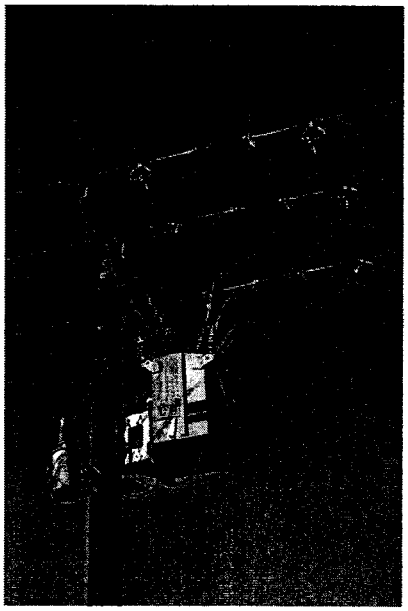
② Use better method to measure range – eg. use white paper over carbon paper for ball to land on – this leaves clear mark of where ball landed which can then be used to measure range. (1)

(e) Explain why the initial velocity of the ball decreases as θ increases, even though the force provided by the spring remains the same. **1**

For $\theta \neq 0°$, the component of the ball's weight down the launch platform increases as θ increases. Thus, the same applied force from spring provides less net force on ball, as θ increases. (1)

QUESTION 14 (6 Marks) **Marks**

(a) Identify the structure attached to the power pole in the photograph at the right and discuss the need for these structures in transferring electrical energy from a power station to its point of use. **4**



Transformer (1) - electricity from power station is most efficiently transmitted over large distances at high voltages. Transformers at power station step the voltage up to ≈ 330kV and (1) reduce the current to very low values. This reduces heat loss in the power lines since heat loss ∝ square of current. (1) Transformers are then used at a series of substations closer to the point of use to step the voltage back down to appropriate values - eg 240V for use in the home. (1)

Fig. 1

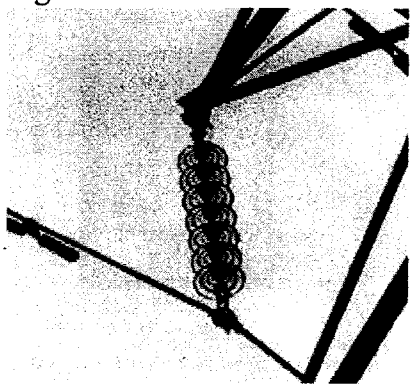
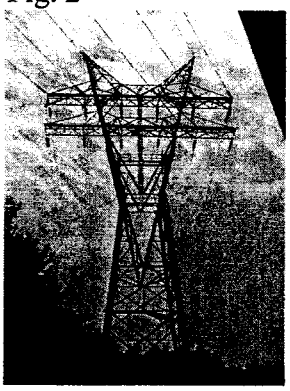


Fig. 2



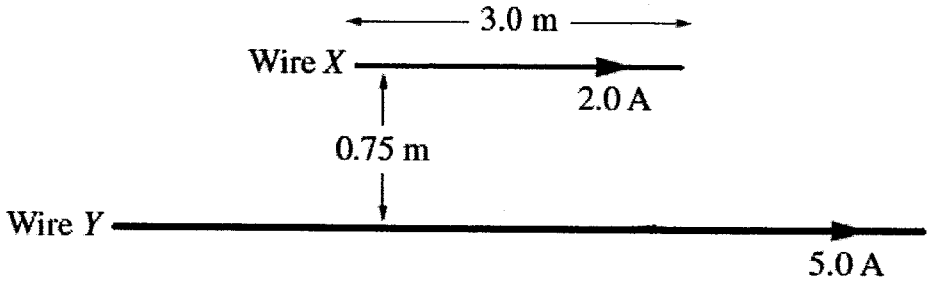
(b) With reference to Figures 1 and 2 above identify how transmission lines are insulated from supporting structures and protected from lightning strikes. **2**

Fig. 1 - A series of skirt-shaped, plastic or ceramic ~~insulators~~ (1) insulators separate transmission lines from supporting structures.

Fig. 2 - 2 shield wires are run above all other wires on high transmission towers to protect the lines from lightning strikes. (1)

QUESTION 15 (6 Marks) **Marks**

Two parallel wires are separated by a distance of 0.75 m. Wire X is 3.0 m long and carries a current of 2.0 A. Wire Y can be considered to be infinitely long and carries a current of 5.0 A. Both currents flow in the same direction along the wires.



1

(a) What is the direction of the force that exists between the two wires?

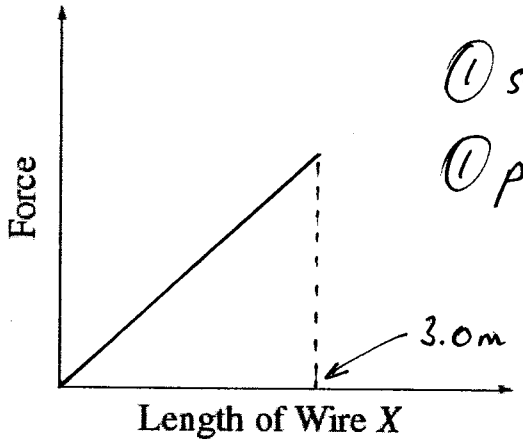
Attractive (1)

2

(b) On the axes, sketch a graph that shows how the force between the two wires would vary if the length of Wire X was decreased.

$F = \left(k.\frac{I_1 I_2}{r}\right).l$

$F \propto l$



(1) straight line ($F \propto l$)

(1) passing thru (0,0) or showing 3.0m length of wire X or some other relevant reference point.

3

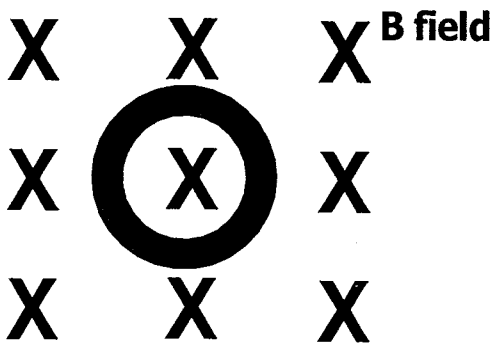
(c) In your Physics course you have performed a first-hand investigation to demonstrate the motor effect. Explain how your results demonstrated that effect.

Suspended square coil of wire vertically from supports so that the (1) bottom side of coil lay between the poles of a magnet. When current was passed through the coil, the side of coil in magnetic (1) field moved forward or backward depending on direction of current. These results clearly showed that a current-carrying wire in (1) a magnetic field experiences a force. This is the motor effect.

QUESTION 16 (4 Marks)

Marks

In the diagram below a thin loop of copper wire is sitting stationary in a uniform magnetic field directed down into the plane of the page. The magnetic field is supplied by an electromagnet with the north pole sitting above the plane of the page and the south pole sitting below.



(a) Describe how a potential difference could be generated within the loop without touching or moving the copper loop. **2**

A change of ~~flux~~ magnetic flux with time must be achieved. (1) This can be done by turning the field off, increasing the field strength, varying the field strength up or down or moving the electromagnet to move the field relative to the coil.

(1) – for ONE of these

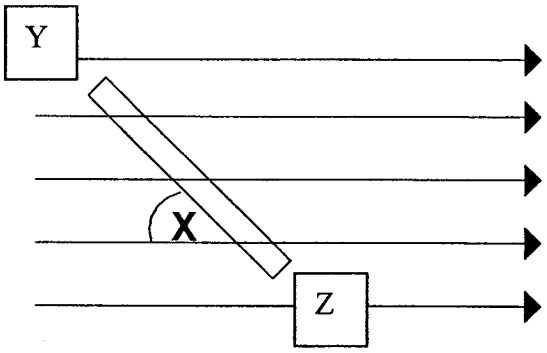
(b) Assume the potential difference across the loop produces a clockwise current viewed from above the plane of the page. Use Lenz's Law to explain how such a current direction could be achieved. **2**

Clockwise current strengthens field in middle of loop. By Lenz's Law an induced emf opposes the change that caused it. (1) Therefore the current in loop could have been produced as a result of turning off the $\vec{B}$ field. (1)

(or by moving the $\vec{B}$ field sideways ~~[illegible]~~ in any direction to leave the loop outside the field)

QUESTION 17 (1 Mark) **Marks**

The conductor shown below is lying in a magnetic field at an angle of $X = 30^\circ$ to the field. It is carrying a current from Y to Z. **1**



State the direction of the force on the conductor.

Up perpendicular to plane of page. (1)

QUESTION 18 (2 Marks)

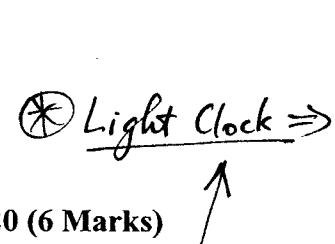
It can be shown experimentally that a DC electric motor operating at full speed uses less current than an identical motor running at half speed. Explain this observation. **2**

Back emf in an electric motor opposes the source emf. (1)
Back emf ∝ speed of coil in motor, so the faster the motor runs, the higher the back emf, the lower the net emf across the circuit and the lower the current drawn by the motor. (1)

QUESTION 19 (3 Marks) many possibilities

Describe a first-hand investigation that you have performed to demonstrate the production of an alternating current. **3**

We used an AC generator. A coil sitting between the poles of a magnet was rotated mechanically (by hand). (1)
Oscilloscope probes were attached to the brushes in contact with the slip rings attached to each side of the coil. (1)
As the coil was rotated, an AC voltage waveform was displayed on the oscilloscope screen. The waveform clearly displayed (1) the typical sinusoidal positive and negative oscillation of AC voltage.



Marks – ① for name of an appropriate thought expt.
③ for recount of expt.
② for discussion – thought + reality
Marks 6

QUESTION 20 (6 Marks)

Recount ONE of Einstein's thought experiments involving mirrors and/or trains and use this experiment to discuss the relationship between thought and reality.

Einstein imagined a "light clock" in which time is measured by bouncing a light beam between two mirrors. The clock ticks once for each up and down motion of the light. Einstein developed a thought experiment in which he considered the time taken for one tick of the clock as seen by two different observers. One observer travelled on a train with the light clock. For him, one tick of the clock was found to be equal to $t_0 = 2L/c$, the distance travelled by the light ($2L$) divided by the speed of light (c). The other observer watched the train as it passed through a station at constant speed V relative to him. Einstein showed that this observer would see the time taken for one tick of the clock as: $t = t_0 / \sqrt{1 - \frac{v^2}{c^2}}$. Clearly, the time interval corresponding to one tick of the light clock is larger for the observer on the station platform than for the observer on the train. Einstein interpreted this result as meaning that time in a moving reference frame appears to go slower relative to a stationary observer. This result is called "time dilation".

Clearly, until the result of this thought experiment could be put to the test in the real world, it remained in the realm of unsupported theory. Eventually, natural particles called μ-mesons were found whose behaviour could only be explained satisfactorily using the idea of time dilation. Since then, many experiments have been done on particle lifetimes in particle ~~and~~ accelerators that also confirm that time dilation is a real phenomenon.

End of Exam

Thus, thought experiments are extremely important tools in physics since they allow theory to move forward tentatively even before the theory can be tested. However, before the results of thought experiments can be accepted as accurate predictions their foundation in reality must be confirmed by valid experimentation.