ST. MICHAEL'S INSTITUTION, IPOH
STPM Trial Examination - 2009
Upper Six Sciences

Physics 2
(960/2)
2 hr 30 min

Full Name: ______________________ Class No.: ______ (as in the Class Register) Class: Upper Six Science ____

Instructions to candidates:

Answer **all** *the questions in Section A in the* ***spaces provided****. All working* **must** *be shown. For calculations, relevant values of constants in the Data Booklet* must be used. For numerical answers, units* **must** *be quoted wherever they are appropriate.*

Answer any **four** *questions from Section B. For this section, write your answers on the answer sheets (test pad) provided. Begin each answer on a fresh sheet of paper, and* ***arrange*** *your answers in* ***numerical order****.* ***Tie*** *your answer sheets to this question booklet (from page 1 to page 6* ***only****).*

* *If necessary, use the values of constants provided on page 10 in this question booklet .*

This question booklet consists of **10** printed pages

Section A

Answer ***all*** *the questions in this section.*

1 (a) Define a vector quantity.

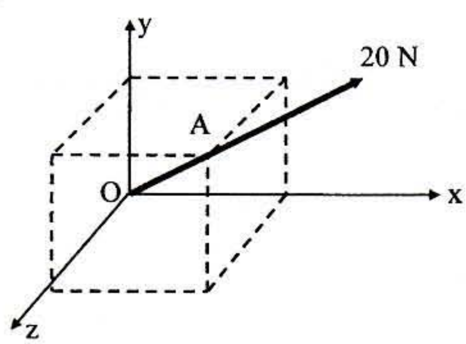
.... [1]

....

(b) A rigid wire frame is in the form of a cube. A force of 20 N is applied along a diagonal from the origin O to a point A which is diagonally opposite to O. Refer to the Figure on the right.

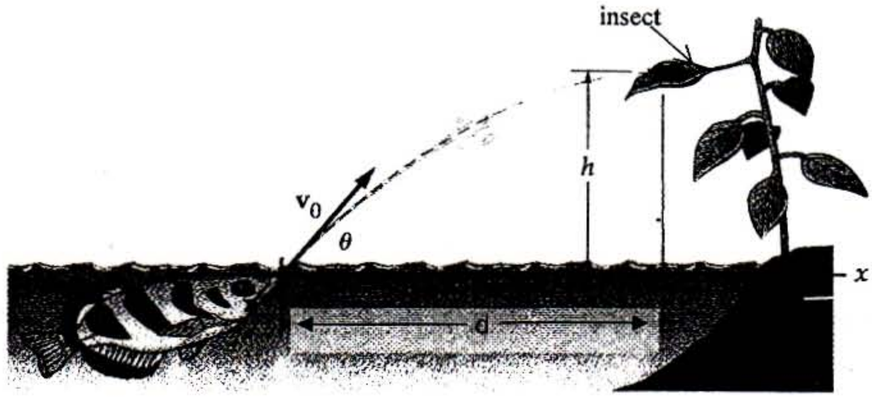
Three forces of *equal* magnitude, each parallel to a side of the cube, are then applied at point O.

Determine the magnitude and direction of these three forces so that they will balance the 20 N force.



[4]

2 The archerfish hunts by dislodging an unsuspecting insect from its resting place with a stream of water expelled from the fish's mouth. Suppose the archerfish squirts water with an initial speed of $2.5\ m\ s^{-1}$ at a beetle on a leaf 4.0 cm above the water's surface, as shown below.



(a) If the fish aim in such a way that the stream of water is moving horizontally when it hits the beetle, what is the launch angle, θ?

[2]

(b) How much time does the beetle have to react?

[2]

(c) What is the horizontal distance, *d*, between the fish and the beetle when the water is launched?

[1]

3 Figure (a) shows the bone and muscle structure of a person's arm holding a 5.0 kg mass in equilibrium. The forearm is horizontal and is at right angles to the upper arm. Figure (b) shows the equivalent mechanical system. F_M is the force exerted by the biceps muscle and F_J is the force at the elbow joint.

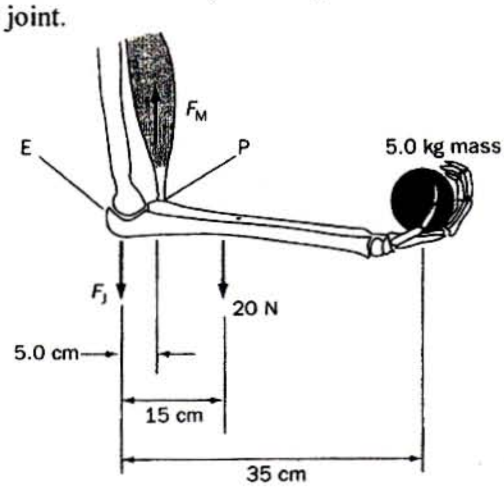


Figure (a)

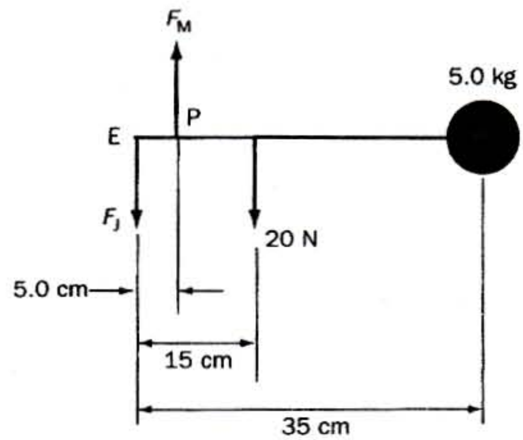


Figure (b)

(a) (i) Suggest a reason why a 20 N force has been included in this system. [1]

....

....

(ii) State the condition(s) that must be met by the forces when the arm is in equilibrium. [2]

....

....

....

....

(b) Calculate the magnitude of the force F_M.

[1]

(c) In many athletes, the distance between the elbow joint (E) and the muscle attachment (P) is greater than 5.0 cm. Explain why this is an advantage in lifting and throwing events.

....

.... [1]

4 (a) State the first law of thermodynamics.

.... [1]

....

....

(b) Explain the following observations:

(i) when gas from an aerosol can is suddenly released, the container becomes cooler. [2]

....

....

....

(ii) while pumping up a bicycle tyre, the pump barrel becomes warmer. [2]

....

....

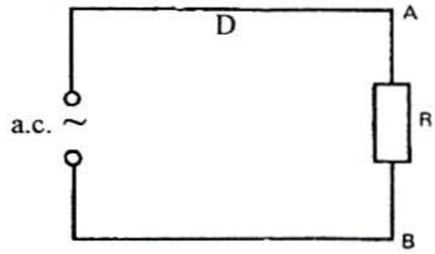
....

5 An ideal solenoid consists of 1000 turns of wire per cm wound around an air-filled cylindrical structure. The solenoid is of 2.0 cm long and cross-sectional area 1.8 cm^2. A current of 2.0 A passes through the wire.

(a) Calculate the magnetic flux in the centre of the solenoid. [3]

(b) Calculate the self-inductance of the solenoid. [2]

6 A sinusoidal a.c. supply is applied to the circuit as shown below.



(a) (i) Write down the equation representing the potential difference between A and B. [1]

....

(ii) On Graph I below, sketch the variation with time of the potential difference between A and B for **two** cycles. [1]

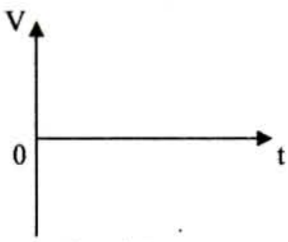
(b) A diode is then connected to the circuit at point D. On Graph II below, sketch the variation with time of the potential difference between A and B for **two** cycles. [1]

(c) (i) Describe how you would modify the circuit in order to smoothen the p.d. across AB. [1]

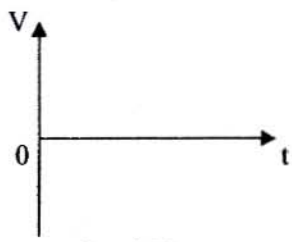
....

....

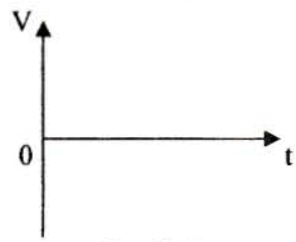
(ii) **After** the modification, sketch the variation with time of the potential difference between A and B for **two** cycles on Graph III below. [1]



Graph I



Graph II



Graph III

7 (a) What is a photon?

.... [1]

....

(b) A p.d. (V) is applied across a photocell as shown in *Figure (a)*. The photocell is then illuminated with monochromatic light of wavelength 365 nm. The current in the circuit is measured for various values of V. The results are shown in *Figure (b)*.

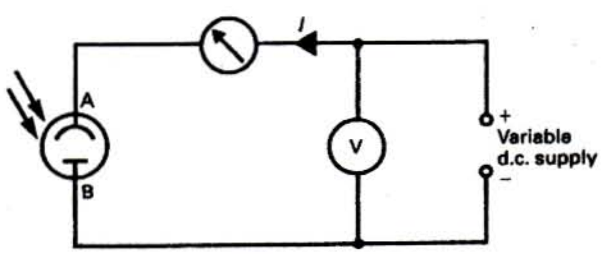


Figure (a)

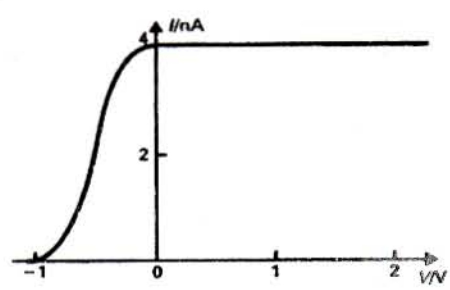


Figure (b)

(i) Deduce the value of the stopping potential. [1]

....

(ii) Calculate the maximum kinetic energy of the photoelectrons emitted.

[1]

(iii) Determine the work function of the cathode material.

[2]

8 The initial number of atoms in a 4.0 g radioactive element is 8.0×10^{21}. The half-life of the element is 5 hours.

(a) Calculate the number of atoms which decay in 12 hours. [4]

(b) Determine the mass of the *radioactive* element left after 24 hours. [1]

Section B

*Answer any **four** questions in this section*

9 (a) Describe briefly the characteristics of a projectile motion. [2]

(b) A ball-bearing of mass 50 g rolls off the edge of a horizontal platform at a height 2.4 m and strikes the floor at a horizontal distance of 3.2 m from the edge of the table.

(i) Calculate the time taken by the ball-bearing to reach the floor. [2]
(ii) Determine the speed of the ball-bearing just before it falls. [2]
(iii) Calculate the magnitude and direction of the velocity of the ball-bearing just before it hits the floor. [5]
(iv) Determine the average power of the ball-bearing. [4]

10 (a) (i) State Newton's law of universal gravitation. [2]
(ii) Define *gravitational field strength.* [1]
(iii) Use your answer to part (i) and (ii) to show that the magnitude of the gravitational field strength at the earth's surface (E_o) is given by the expression $E_o = \frac{GM}{R^2}$ where M is the mass of the earth, R is the radius of the earth and G is the gravitational constant. [2]

(b) A communication satellite is in an orbit such that its period of revolution around the earth is 24 hours.

(i) Explain the significance of this period. [2]
(ii) What is the term given to this particular orbit? [1]
(iii) Show that the radius of the orbit, R_o, is given by $R_o = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$ where T is the period of the orbit, and G and M have the same meaning as in (a)(iii). [2]

(c) Estimate the minimum kinetic energy which must be given to a satellite of mass 2500 kg at the earth's surface for it to reach a point which is at a distance R_o from the centre of the earth. State **two** assumptions made in your calculations. [5]

[$M = 6.0 \times 10^{24}$ kg, $R = 6.4 \times 10^6$ m]

11 (a) (i) State **two** assumptions of an ideal gas. [2]

(ii) State **two** physical conditions under which a real gas behaves as an ideal gas. [2]

(iii) A 0.45 m^3 tank contains 8.0 kg of butane gas. Assuming that the gas behaves as an ideal gas, calculate its pressure at 27 °C. [3]

[Molecular mass of butane is 58 g mol^{-1}]

(iv) Butane gas normally behaves as a real gas. The actual pressure of the butane gas is higher than the calculated value in (a)(iii). Give a reason. [1]

(b) (i) What is meant by the *degrees of freedom* of a gas molecule? [1]

(ii) Write an expression relating the total kinetic energy E of a gas molecule to the number of degrees of freedom f. Explain any other symbols used. [2]

(iii) The escape velocity of Mars is 5.0×10^3 m s^{-1}. If the temperature of Mars is 300 K, determine whether oxygen gas can exist on the planet. [4]

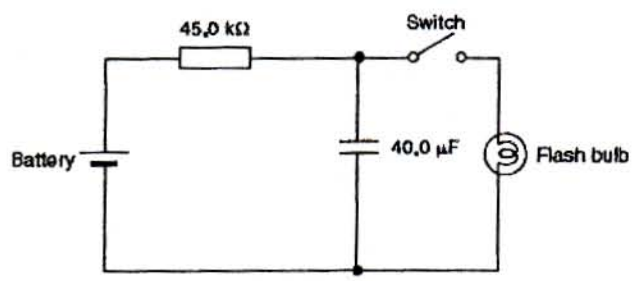
[Molecular mass of oxygen is 32 g mol^{-1}]

12 (a) Two thin conducting plates have an area of 0.50 m^2 each. They are placed parallel to each other and 20 mm apart. One plate is maintained at +75 V while the other at –75 V by a d.c. supply.

(i) Determine the amount of charge stored on each plate. [3]

(ii) Calculate the energy per unit volume stored in the electric field between the plates. [3]

(b) The figure shows a simple circuit of the photographic flash used in a camera.



The capacitance of the capacitor is 40.0 μF, and the resistance of the resistor is 45.0 kΩ.

(i) Explain how the capacitor functions in this application. [4]

(ii) Calculate the time required to charge the capacitor to 63% so that a good flash can be obtained. [4]

(iii) Suggest a way to reduce the charging time of the capacitor. [1]

13 *Figure (a)* shows how two op-amp are connected together in series. Both are supplied with ± 9.0 V. *Figure (b)* shows how the voltage gain of a non-inverting amplifier depends on frequency.

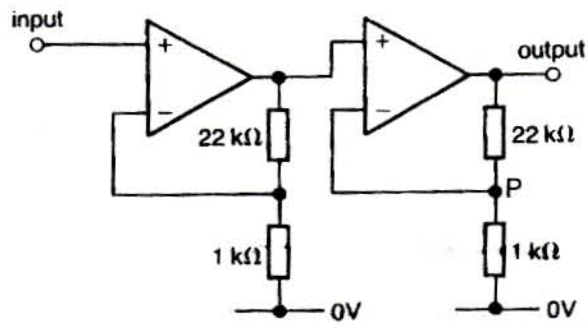


Figure (a)

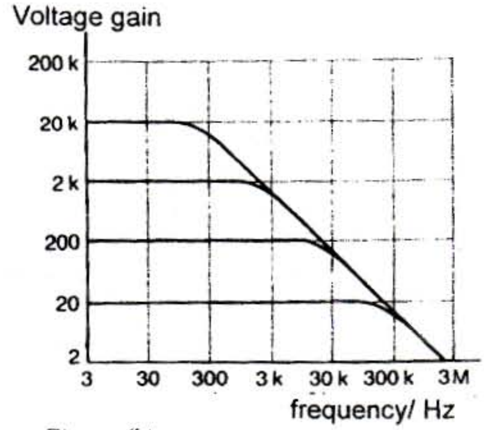


Figure (b)

(a) (i) Name the type of feedback circuit used. [1]
(ii) Explain the meaning of this type of feedback. [1]
(iii) State **two** advantages of this type of feedback. [2]

(b) (i) Calculate the voltage gain of each **individual** amplifier. [1]
(ii) Deduce the voltage gain of the **whole** system. [1]

(c) A steady voltage of -3.0 mV is applied to the input of the system.
(i) Determine the voltage at the output. [1]
(ii) Calculate the electric potential at point P. [2]

(d) A sinusoidal a.c. of peak voltage 30 mV is then applied to the input.

On the same axes, sketch the graph of:
(i) the input voltage against time. [4]
(ii) the output voltage against time.

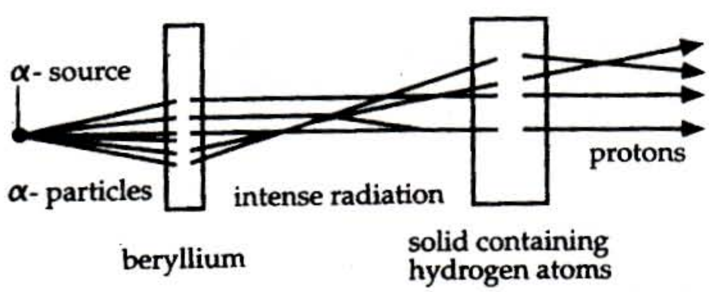
In your graph, label each line carefully and label all the important values on the axes.

(e) Using the graph in Figure (b), estimate the bandwidth of the **whole** system. [2]

14 (a) Give the meaning of each of the following terms.

(i) nucleon number [1]
(ii) proton number [1]
(iii) binding energy [2]

(b) The structure of the nucleus was investigated by the experiment shown in the *Figure below.*



Alpha particles were fired at a piece of beryllium and an intense radiation was found to be emitted from the beryllium. When this radiation entered a hydrogen-rich solid, protons were knocked forward from the solid. The initial reaction in the beryllium is

$$^{4}_{2}He \quad + \quad ^{9}_{4}Be \;\rightarrow\; ^{1}_{0}n \quad + \quad ^{12}_{6}C$$

(i) In the above equation, which symbol is used to represent the alpha particles? [1]
(ii) What information does the symbol give about the alpha particles? [1]
(iii) Suggest, with a reason, which particle is responsible for knocking a proton out of the solid containing hydrogen atoms. [2]
(iv) The intense radiation was originally thought to be γ-rays. Why does the existence of the knocked-forward protons make this impossible? [2]

(c) The masses of the particles in part (b) are as follows.

$^{4}_{2}He$	+	$^{9}_{4}Be$	$\rightarrow$	$^{1}_{0}n$	+	$^{12}_{6}C$
4.00260 u		9.01212 u		1.00867 u		12.0000 u

(i) Calculate the mass defect, in kilogram, in the reaction. [2]
(ii) Hence, find the energy equivalence of this mass defect. Express your answer in MeV. [3]

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960 PHYSICS

Values of constants

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_o	=	8.85×10^{-12} F m^{-1}
		≈	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
Magnitude of electronic charge	e	=	1.60×10^{-19} C
Planck constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant	u	=	1.66×10^{-27} kg
Rest mass of electron	m_e	=	9.11×10^{-31} kg
Rest mass of proton	m_p	=	1.67×10^{-27} kg
Molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
Avogadro constant	L, N_A	=	6.02×10^{23} mol^{-1}
Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
Gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
Acceleration of free fall	g	=	9.81 m s^{-2}

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