MARKING SCHEME . PHYSICS 1

1 (a)(i) Law of principle of homogeneity of dimensions states that "A physical relation is dimensionally correct if the dimensions of fundamental quantities (mass, Length and time) are the same in each and every term on either side of the equation". (01 mark)

(b)(i) $F \propto r^x \eta^y V^z$ ——(1)

$$F = k r^x \eta^y V^z$$

where k = dimensionless constant and x, y and z are the unknown indices.

$$[F] = [r^x][\eta^y][V^z] \quad \text{——— 01}$$

$$[MLT^{-2}] = [L]^x [ML^{-1}T^{-1}]^y [LT^{-1}]^z \quad \text{——— 01/2}$$

Equating the indices of M, L and T on both sides, we have.

$$y = 1,$$
$$x + z - y = 1$$
$$-y - z = -2$$

Solving, gives

$$y = 1 \quad \text{——— 01/2}$$
$$z = 1 \quad \text{——— 01/2}$$
$$x = 1 \quad \text{——— 01/2}$$

Therefore equation (1) become

$$F = k r \eta V \quad \text{——— 01}$$

(b)(i) Absolute error is the difference in the magnitudes of true value and the measured value of a physical quantity (01 mark)

(ii) $Y = \dfrac{F/A}{\delta L/L} = \dfrac{FL}{A\,\delta L}$

$$= \frac{MgL}{\pi r^2 \delta L}, \quad r = \frac{D}{2}$$

$$Y = \frac{4MgL}{\pi D^2 \delta L} \quad \text{——— (01)}$$

$$\therefore \frac{\Delta Y}{Y} = \frac{\Delta L}{L} + \frac{2\Delta D}{D} + \frac{\Delta l}{l}$$ —— (01 mark)

Since g is constant, its error is zero.

$\frac{\Delta Y}{Y}$ = $\therefore$ Maximum permissible error in Y

$$= \frac{\Delta Y}{Y} \times 100\%$$

$$= \left(\frac{\Delta L}{L} + \frac{2\Delta D}{D} + \frac{\Delta l}{l}\right) \times 100$$

$$= \left(\frac{0.1}{325} + 2 \times \frac{0.001}{0.043} + \frac{0.001}{0.227}\right) \times 100$$ (01 mark)

$$= 5.123\%$$ —— (01 mark)

2 (a) (i) ~~This is because, in the absence of any net force on a body, the body is either at rest or it moves with a constant speed in a straight line.~~
~~Therefore in order to change the motion, net external force is required. This means that every body has a tendency to maintain its state of rest or of uniform velocity.~~

2(b) (b)(ii) ~~Rain falls vertically onto a plane roof, 1·5m square, which is inclined to the horizontal at an angle of 30°. The rain drops strike the roof with a vertical velocity of 30m/s, and a volume of 2·5 x10⁻²m³ of water is collected from the roof in one minute. Assuming~~

2a (ii) (b)(i) from

$$F = V\frac{dm}{dt}, \quad dm = \frac{\rho dV_o}{dt} \quad \text{—— (01)}$$

$$F = V\rho\frac{dV_o}{dt}, \quad \frac{dV_o}{dt} = \text{Rate of change of volume of water collected from the roof.}$$

$$F = 3\,m/s \times 1000 \times \frac{2\cdot5\times10^{-2}\,m^3}{60} \quad \text{—— (01)}$$

$$= 1\cdot25\,N \quad \text{—— (01)}$$

(b)(ii) Pressure normal to the roof, $P = \frac{F_N}{A}$

Since the roof is inclined at an angle of 30°, the force F_N is,

$$F_N = F\cos\theta \quad \text{—— (01)}$$

~~$F_N = 1\cdot25$~~, then

$$P = \frac{1\cdot25\times\cos30^\circ}{1\cdot5\times1\cdot5}$$

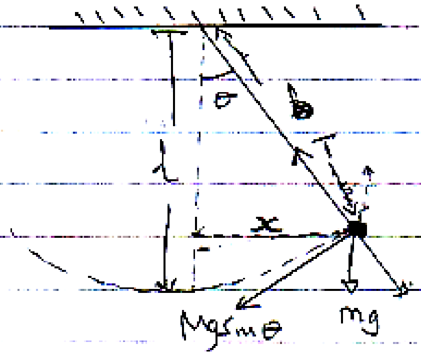
$$= 0\cdot48\,N/m^2 \quad \text{—— (01)}$$

b(i) Periodic motion is the motion which repeats itself after a regular interval of time (02 marks)

while

Oscillatory motion is the motion ~~of a body~~ in which a body moves along the same path to and fro about a definite point (01 mark)

(ii) Consider the following diagram



m = Mass of a pendulum

——— 0½ (01)

At equilibrium,

Restoring force = $-mg\sin\theta$, ——— 0½

But $\sin\theta = \frac{x}{l}$.

$$F = -mg\frac{x}{l}$$ ——— 0½

Acceleration of a bob, $a = \frac{F}{m}$.

$$ma = \frac{-mgx}{l}.$$

$$a = \frac{-gx}{l}.$$ ——— 0½

But, for S.H.M,

$$a = -\omega^2 x,$$ ——— 0½

$$-\omega^2 x = \frac{-gx}{l}$$

$$\left(\frac{2\pi}{T}\right)^2 = \frac{g}{l}$$

$$\frac{4\pi^2}{T^2} = g/l$$

$$\frac{T^2}{4\pi^2} = l/g.$$

$$\sqrt{T^2} = \sqrt{4\pi^2 \cdot l/g}$$

(01)

$T = 2\pi\sqrt{l/g}$., hence showed, this shows that T is independent to mass of a pendulum.

3. (i) This is because inside the ~~artifiod~~ artificial satellite, $g = 0$.

from

$T = 2\pi\sqrt{l/g}$, so when $g = 0$ that $T \longrightarrow \infty$, hence the pendulum will not vibrate. (2 marks)

(ii) from

$$\frac{Mv^2}{r} = mg.$$

$$v^2/r = g. \quad \text{———— (01)}$$

$v = \omega r$; $\omega = 2\pi/T$.

$$g = \frac{(\omega r)^2}{r}.$$

$$g = \omega^2 r.$$

$$g = \frac{4\pi^2}{T^2} \cdot r$$, r = ~~height of sate~~ distance from centre of the earth to satellite.

$$r = \frac{gT^2}{4\pi^2}$$

$$r = \frac{9.8 \times (90 \times 60)^2}{(3.14)^2 \times 4}$$

$$r = 7238 \times 10^3 m.$$

$$= 7238 km. \quad \text{———— (01)}$$

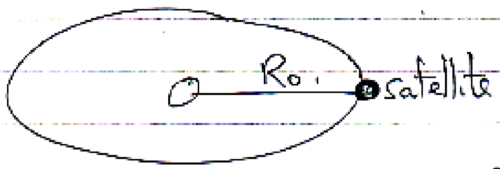
Since the radius of the earth is 6370km, the height of the satellite above the earth surface is

$h = r -$ earth radius

$7238 - 6370$

$= 868 km$ ———— (01)

(b) Consider the following



Centripetal force, $F_1 = M\omega^2 R_0$ ——— (1) ——— (01)

Newton's law of universal gravitation

$$F_2 = \frac{GMM_e}{R_0^2}.$$ ——— (01)

M_e = Mass of the earth , m = Mass of orbit

At equilibrium,

$$F_1 = F_2$$

$$M\omega^2 R_0 = \frac{GMM_e}{R_0^2}$$ ——— (01)

$$\omega^2 R_0 = \frac{GM_e}{R_0^2}$$

$$\omega^2 = \left(\frac{2\pi}{T}\right)^2.$$

$$\frac{4\pi^2}{T^2} \cdot R_0 = \frac{GM_e}{R_0^2}$$

$$R_0^3 = \frac{GM_e T^2}{4\pi^2}$$ ——— (01)

$$R_0 = \sqrt[3]{\frac{GM_e T^2}{4\pi^2}}$$ ——— (01)

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$$\omega^2 R_0 = \frac{GM_e}{R_0^2}$$

$$\omega^2 = \left(\frac{2\pi}{T}\right)^2.$$

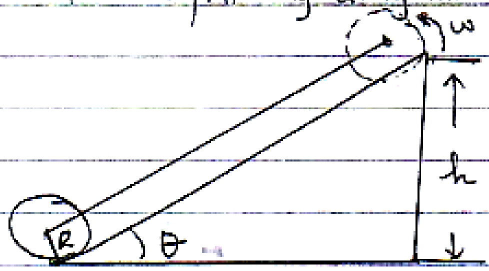
$$\frac{4\pi^2}{T^2} \cdot R_0 = \frac{GM_e}{R_0^2}$$

$$R_0^3 = \frac{GM_e T^2}{4\pi^2} \quad \text{——— (01)}$$

$$R_0 = \sqrt[3]{\frac{GM_e T^2}{4\pi^2}} \quad \text{——— (01)}$$

4 (a)(i) The swimmer can increase the number of loops in air by pulling his arms and legs inward. i.e by decreasing the moment of inertia. By doing so, the angular velocity ω increases because angular momentum $(= I\omega)$ remains constant.
(01 mark)

(ii) Consider the following diagram.



—— 01

$$I = \frac{1}{2} MR^2 \text{ about an axis through its centre}$$

$$\text{But } R = V/\omega.$$

$$I = \frac{1}{2} M \frac{V^2}{\omega^2} \quad \text{—— (01)}$$

The conservation of energy of a rolling object at the bottom can be expressed as

$$Mgh + 0 = 0 + \frac{1}{2} I\omega^2 + \frac{1}{2} MV^2$$

$$Mgh = \frac{1}{2}\left(\frac{1}{2} \frac{MV^2}{\omega^2} \cdot \omega^2\right) + \frac{1}{2} MV^2 \quad \text{—— (01)}$$

$$Mgh = \frac{1}{4} MV^2 + \frac{1}{2} MV^2$$

$$gh = \frac{1}{4} V^2 + \frac{1}{2} V^2$$

$$gh = \frac{3}{4} V^2$$

$$V^2 = \frac{4gh}{3}$$

—— (01)

$$V = \sqrt{\frac{4gh}{3}}, \text{ hence proved.}$$

(b) Kinetic energy of rotating rigid body is given by
$K.E = \frac{1}{2} I \omega^2$ (01)

But $I = \frac{1}{2} Mr^2$ (01)

$K.E = \frac{1}{2}\left(\frac{1}{2}Mr^2\right)\omega^2$

$= \frac{1}{2}\left(\frac{1}{2}Mr^2\right)(2\pi f)^2$ (01)

$K.E =$ ~~30kg~~

$\frac{1}{4} \times 30 \times (0.5)^2 \times 4 \times (3.14)^2 \times \left(\frac{300}{60}\right)^2$ (01)

$= 1850.6\,J$

$\therefore$ K.E of the fly wheel about an axis through its centre is $1850.6\,J$. (01)

5 (a)(i) Transfer of heat: When two bodies at different temperatures are put in thermal contact, heat flows from a body at higher temperature to a body at lower temperature till they contain a common intermediate temperature. According to second law of thermodynamics, the entropy of the system increases in this process. (01)

(ii) Expansion of a gas: (01)

a(ii) (b) Internal energy is given by

$$U = \frac{m}{M} C_v T, \quad C_v = \frac{R}{\gamma - 1}$$

$$U = \frac{mRT}{M(\gamma-1)} \text{ --- } 0\tfrac{1}{2}$$

$$U = \frac{PV}{\gamma - 1}$$

or

$$\Delta U = \frac{P \times \Delta V}{\gamma - 1} \quad \text{at constant pressure}$$

$$= \frac{W}{\gamma - 1} \text{ --- } 0\tfrac{1}{2}$$

According to first law of thermodynamics

$$Q = \Delta U + W$$

$$= \frac{W}{\gamma - 1} + W$$

$$= \frac{\gamma W}{\gamma - 1} \text{ --- } 01, \quad W = 2, \gamma = 1 \cdot 4$$

$$Q = \frac{1\cdot4 \times 2}{1\cdot4 - 1} =$$

$$= 7\,J. \text{ --- } 01$$

5 (b) $E = a\theta + \frac{b\theta^2}{2}$

Since θ_N obtained at E_{maxm},

(i) then, $\frac{dE}{d\theta} = a + b\theta$. from maximum e.m.f, $\frac{dE}{d\theta} = 0$. —— $0\frac{1}{2}$

$0 = a + b\theta$.

$\theta_N = -a/b$. —— $0\frac{1}{2}$

$\theta_N = \frac{-10\mu V°C^{-1}}{-0.05\mu V/°C}$

$= 200°C$ —— 01

(ii) $\theta_i = 2 \times \theta_N$ —— $0\frac{1}{2}$

$= 2 \times 200$

$= 400°C$ —— $0\frac{1}{2}$

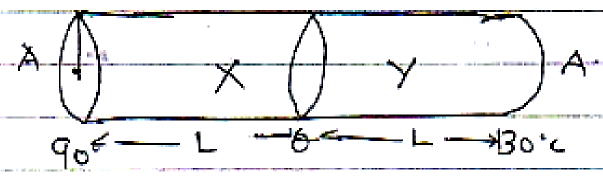
(iii) $E_{maxm} = a\theta_N + \frac{b\theta_N^2}{2}$ —— $0\frac{1}{2}$

$= 10\mu V°C \times 200 - 0.05\mu V°C \times \frac{(200)^2}{2}$ —— $0\frac{1}{2}$

$E_{max} = 1000\,\mu V$ —— 01

6 (a)(i) It is ~~because~~ tile is a better heat conductor than wood. The heat transfered from your foot to the wood is not conducted away rapidly. So the wood quickly heat up on its surface to the temperature of your foot. But the tiles conducts the heat away rapidly and thus can take more heat from your foot, so its surface temperature drops. (~~02 marks~~) (02 marks)

(ii)(b) Case I: Series arrangement



for series arrangement.

$$\frac{K_x A(\theta_1 - \theta)}{L} = \frac{K_y A(\theta - \theta_2)}{l} \quad \text{———} (01)$$

$$400(90 - \theta) = 200(\theta - 30).$$

$$2(90 - \theta) = \theta - 30$$

$$\cancel{180} - 2\theta = \theta - 30°$$

$$210°C = 3\theta$$

$$\theta = 70°C \qquad (01\tfrac{1}{2})$$

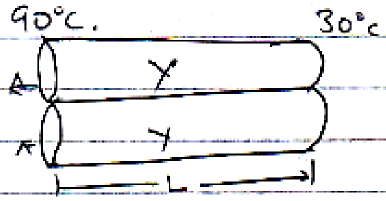
but rate of heat flow, $\frac{dQ}{dt} = \frac{K_x A(\theta_1 - \theta)}{L}$ or

$\frac{K_Y A(\theta - \theta_2)}{l}.$

$$\frac{dQ}{dt} = \frac{400A(90 - 70)}{l} \qquad (0\tfrac{1}{2})$$

$$\left(\frac{dQ}{dt}\right)_1 = \frac{8\,000A}{L} \quad \text{———} (1) \qquad (01)$$

Case II : Parallel arrangement.



for parallel,

$$\frac{d\varphi}{dt} = \frac{K_X A(\theta_1 - \theta_2)}{L} + \frac{K_Y A(\theta_1 - \theta_2)}{l} \quad (\cdot 1)$$

$$\frac{400A(90-30)}{L} + \frac{200A(90-30)}{L}$$

$$\left(\frac{d\varphi}{dt}\right)_2 = \frac{36000A}{L} \text{ ——— (ii)} \quad \left(\begin{matrix}01 \\ 0\frac{1}{2}\end{matrix}\right)$$

Ratio of parallel arrangement to that of series arrangement

$$\frac{\left(\frac{d\varphi}{dt}\right)_2}{\left(\frac{d\varphi}{dt}\right)_1} = \frac{36{,}000A}{L} \times \frac{L}{800A}$$

$$= 9/2.$$

$$= 9:2. \quad (01).$$

6 (a) (ii) ~~The layer of ice that forms on top of a lake or pond, provides some insulation that helps the waterbody retain its heat~~

~~Ore~~

Only the top layer of the lake freezes. Underneath the frozen upper layer, the water remains in its liquid form and does not freeze. Also oxygen is trapped beneath the layer of ice
(02 marks)

7 (a) ~~Mottet~~ Mulching
→ Shading
→ Sheltering

Any 2 points = (02 marks)

(ii) → It may cause earthquakes
→ Potential emissions
→ Surface/land Instability

Any three points = 03 (marks)

(b) Aerial ~~influence~~ resulting from a series of processes occuring in the atmosphere. (01) mark
- Aerial environment include the flowing
(i) Air ~~resistance~~ temperature (01) mark
→ Can increase plant growth
→ Balance water in plants through transpiration

(ii) Rainfall (01) mark
(iii) Humidity (01) mark
(iv) Wind (01) mark

8 (e)(i) Inorder to minimize/reduce the heat lost during transmission

(ii) from

$$W = \frac{1}{\sqrt{LC}} \quad \text{———} \tfrac{1}{2}$$

$$= \frac{1}{\sqrt{10\times10^{-3}\times1\times10^{-6}}}$$

$$= 10^4\ rad/s. \quad \text{———} \tfrac{1}{2}$$

then, $w' = w - \frac{20}{100} \times w$

$$w' = 10^4 - \frac{20}{100} \times 10^4$$

$$w' = 8\times10^3\ rad/s \quad \text{———} \tfrac{1}{2}$$

At this frequency,

$$X_L = W'L$$

$$= 8\times10^3\times10\times10^{-3}$$

$$= 80\Omega \quad \text{———} \tfrac{1}{2}$$

$$X_c = \frac{1}{W'c} = \frac{1}{8\times10^3\times10^{-6}}$$

$$= 125\Omega \quad \text{———} \tfrac{1}{2}$$

$$Z = \sqrt{R^2 + (X_L - X_c)^2}$$

$$= \sqrt{3^2 + (80-125)^2}$$

$$Z = 45\Omega \quad \text{———} \tfrac{1}{2}$$

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

$$= \frac{20V}{45}$$

$$= 0.4A \text{ ——— } c\tfrac{1}{2}$$

(c) i) Consider the circuit diagram below

$$I = \frac{E_T}{R_T} = \frac{E}{R+r} \text{ ——— } c\tfrac{1}{2}$$

Power output across the load is given by

$$\text{Power} = I^2 R$$

$$\left(\frac{E}{R+r}\right)^2 R$$

$$= \frac{E^2 R}{(R+r)^2} \text{ ——— } c\tfrac{1}{2}$$

$$\frac{dP}{dR} = \frac{E^2[(R+r)^2 - R \times 2(R+r)]}{(R+r)^4}$$

$$= \frac{E^2[R^2 + 2Rr + r^2 - 2R^2 - 2Rr]}{(R+r)^4}$$

$$= \frac{E^2(r^2 - R^2)}{(R+r)^4} \text{ ——— } c1$$

for maximum ~~output,~~ power output, $\frac{dP}{dR} = 0$.

$$\frac{E^2(r^2 - R^2)}{(R+r)^4} = 0 \text{ ——— } c1$$

$r^2 - R^2 = 0$

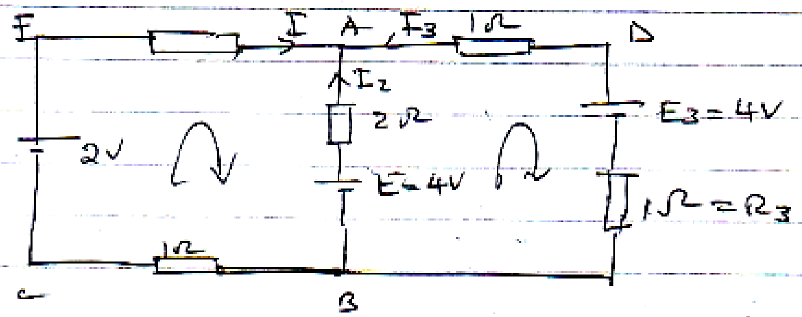
$r^2 = R^2$

$r = R$ ———— 01

∴ Therefore for maximum power output is obtained when $R = r$, hence shown.

(ii) E.m.f is a p.d across the terminal of the cell when it is delivering no current
while
P.d is the p.d across the terminal of the cell when it is delivering current. (01 mark).

(c)



(i) Assume current flows in the direction shown at junction A

$I_1 + I_2 + I_3 = 0$ ——— (i) ——— $0\frac{1}{2}$

Consider loop ABCE

$\cancel{(2I_2) + (1\times I_1) + (1\times I_1) = 4 - 4}$

$(-2I_2 + I_1 + I_1) = 2 - 4$

$-2I_2 + 2I_1 = -2$

$I_2 + I_1 = -1$ ——— (ii) ——— $0\frac{1}{2}$

Consider loop BADF

$(2I_2 + I_3 - I_3) = 4 - 4$

$2I_2 - 2I_3 = 0$ ——— (iii) ——— $0\frac{1}{2}$

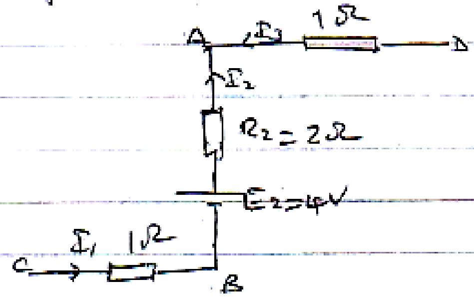
Solving eqn (i), (ii) and (iii), we have,

$I_2 = \frac{1}{3}A$, $I_3 = \frac{1}{3}A$ and $I_1 = \frac{2}{3}A$ ——— $0\frac{1}{2}$

∴ Current through $R_2 = \frac{1}{3}A$. ——— 01

(ii) P.d between C and D

← Consider path CBAD



p.d drop b/n C and C = $\sum$ p.d b/n C and C

$= -(\cancel{1 \times I_1) + 4 + -(2 \times I}$

$: (-1 \times I_1) + 4 + (-2 \times I_2) + (1 \times I_3)$

$= -\frac{2}{3} + 4 + -2 \times \frac{1}{3} + \frac{1}{3}$

p.d = b/n C and D = 3V (02 marks)

Alternatively, taking path CBD

$V_C - I_1 - I_3 - V_D = 0$.

$V_D - V_C = 4 - I_1 \times 1 + I_3 \times 1$

$= 4 - \frac{3}{3} - \frac{1}{3}$

$= 3V$. (02 ~~mar~~

9 (a) Increase in temperature, increases electrical conductivity of semiconductor and decreases in temperature decreases electrical conductivity of semiconductor. (01)

(b)(i) → To overcome thermal run away

→ To keep the operating point unaltered by the changes in the device parameters

→ To ensure proper stability of operating point

($\frac{1}{2} \times 3 = 01\frac{1}{2}$)

b (i) → They do not obey Ohm's law

→ It has two charge carriers which are holes and ele.

→ Conductivity increases with increase in temperature ($\times 3 =$ 03 marks)

(ii) 10 V – provides a reverse bias on the base – collector junction

R_1 = used to vary the D.C operating point to a desired value.

1.5V provides forward bias on the base – emitter junction.

(ii) Capacitor C_1 blocks D.C components.

(iii) From, $I_E = I_B + I_C$.

$I_C = I_E - I_B$

$1 mA - 0.02 mA$.

$I_C = 0.98 mA$. —— $01\frac{1}{2}$

Current gain, $\beta = \frac{I_C}{I_B} = \frac{0.98 mA}{0.02 mA}$

$= 49$. —— $01\frac{1}{2}$

Voltage gain, $A_V = \frac{\Delta V_{CE}}{\Delta V_{BE}}$

$= \frac{\Delta I_C \times R_C}{\Delta I_B \times R_i}$

$$A_v = \beta\left(\frac{R_c}{R_i}\right) \quad \text{— } 01\tfrac{1}{2}$$

$$= 49 \times \left(\frac{5k\Omega}{50km}\right)$$

$$= 4900$$

∴ Therefore the voltage gain = 4900. — $01\tfrac{1}{2}$

c (i) – OR – gate
– NOT – gate
AND – gate

$\left.\right\}$ $01\tfrac{1}{2}$ Ⓒ = $01\tfrac{1}{2}$

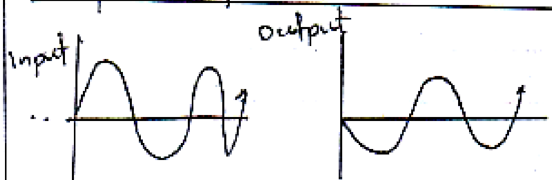
(ii)

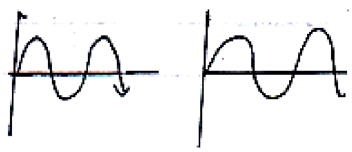
Input				Output		
A	B	C	D	E	F	G
0	0	1	1	1	1	0
0	1	1	0	0	1	1
1	0	0	1	1	0	1
1	1	0	0	1	1	0

1e = 04 marks

10 a (i)

Inverting amplifi.	~~Non inver~~ Non-inverting
– Out put is out phase with input signals	Input signals are in phase with out put signals





Any of one = 02 marks.
Even diagram for them can be an answer.

(ii) What ~~are three distinguishable characteristics of~~
Operational ~~amplifier~~ (