H2 PHYSICS

Exam papers with worked solutions

(Selected from Top JC)

SET D

PAPER 2

ANSWER

Compiled by

THE PHYSICS CAFE

1 (a) (i) Upthrust is the net upward force exerted by a fluid on the object that is immersed (whether fully or partially) in the fluid. 1

It is due to the difference in hydrostatic pressure on the upper and lower surface of the object. 1

(ii) FBD shows 2 *equal* but *opposite (and in line)* arrows, representing upward force of upthrust and downward force of weight. 1

(iii) At equilibrium, weight of block= upthrust = weight of water displaced.

Vol of block × density of brick × g = volume of water × density of water × g

$[(20)(10)(10) \times 10^{-6}]\ (200)\ (g) = [(20)(10)(x) \times 10^{-6}](1024)(g)$ 1

x = (10)(200)/(1024) = 1.95 cm = 0.0195 m 1

(b) When *fully immersed, each block gives maximum support*.

max. force supported by each block = upthrust – weight of the block 1

= vol of block × density of water × g - vol of block × density of block × g
= vol of block × (density of water – density of block) (g)
= $[(20)(10)(10)\text{x}10^{-6}]$ (1024-200) (9.81)
f = 16.17 N 1

To support a man of 90 kg, number of bricks required ≥ weight of man / f
= (90)(9.81)/16.17 = 54.6

Minimum number of bricks required = 55 1
assuming that all the bricks are just submerged.

Alternative:
Assume that n fully submerged blocks are used. At equilibrium,

total upthrust on n blocks ≥ total weight of n blocks + weight of the person

$n\ [(20)(10)(10) \times 10^{-6}]\ (200)\ (g) + (90)(g) = n\ [(20)(10)(10) \times 10^{-6}](1024)(g)$
……
$n \geq 54.6$,

Minimum number of bricks required = 55

2 (a) (i) The gravitational field strength at a point is the gravitational force per unit mass acting on a mass placed at that point. 1

(ii) The gravitational potential at a point is defined as the **work done per unit mass** by an external force in bringing a body **from infinity to that point**. 1

1

(b) (i) Change in gravitational potential,

$$\Delta\phi = -\frac{GM}{R+h} - \left(-\frac{GM}{R}\right)$$ 1

$$= -\left(\frac{(6.67\times10^{-11})(6.0\times10^{24})}{(6.4\times10^{3}+1.3\times10^{4})\times10^{3}}\right) + \left(\frac{(6.67\times10^{-11})(6.0\times10^{24})}{(6.4\times10^{3})\times10^{3}}\right)$$ 1

$$= -2.063\times10^{7} + 6.253\times10^{7}$$

$$= 4.190\times10^{7}$$ 1

$$= 4.2\times10^{7}\ \text{J kg}^{-1}$$

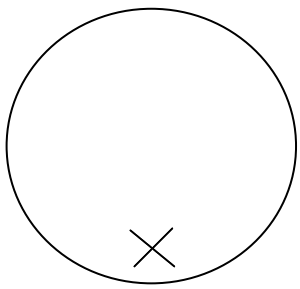
(ii) With negligible air resistance,
Loss in KE = Gain in GPE
$KE_{initial} - KE_{final} = PE_{final} - PE_{initial}$

$$\frac{1}{2}mv^2 - 0 = m(\Delta\phi)$$ 1

$$v = \sqrt{2(\Delta\phi)} = 9200\ \text{m s}^{-1}$$ 1

3 (a) $\omega = 2\pi f = 2\pi(12) = 75.4$ rad s^{-1} 1

(b) (i)



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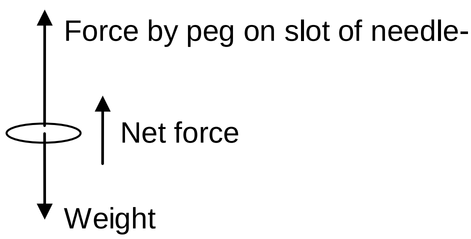
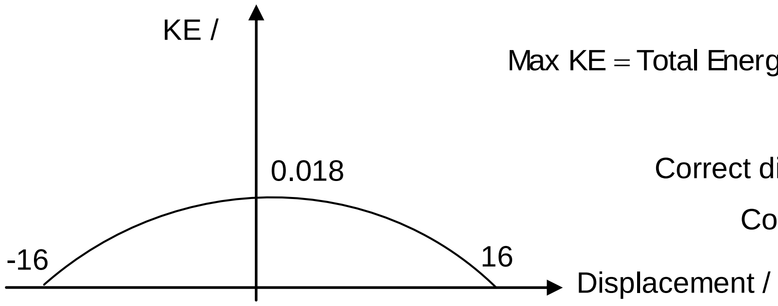
(ii) Consider the free body diagram of the slot at the bottom position.



1

Net force = Force by peg on slot – weight 1
$mx_0\omega^2$ = Force by peg on slot – mg
Force by peg on slot = $(0.025)(0.016)(75.498)^2 + (0.025)(9.81)$ 1
= 2.52 N

(c)



Max KE = Total Energy $= \frac{1}{2} m\omega^2 {x_0}^2$

Correct shape 1

Correct displacement 1

Correct energy 1

4 (a) Loss in kinetic energy = gain in electric potential energy
= q ($V_Z - V_X$)
= (-1.60 x 10^{-19}) (0 – (-100)) 1
= 1.60 x 10^{-17} J 1

(b) (i) Magnitude of field strength = |ΔV/Δx|
= (300 – 100)/(2.3×10^{-2}) 1
= 8700 V m^{-1} 1

(ii) Direction of field is downward. 1

(c) $F = qE = (1.60 \times 10^{-19})(8696) = 1.39 \times 10^{-15}\ N$ 1
Direction is upwards. 1

5 (a) In circuit P, there is no current since the voltmeter has infinite resistance. 1
Hence the potential difference across the voltmeter is the e.m.f of the 3 cells.

In circuit Q, there is a current therefore there is a voltage drop across the internal resistance of the cell. Hence the potential difference the voltmeter read is lower than the e.m.f. 1

(b) Using $\varepsilon = V + Ir$

$$4.5 = 3.3 + \frac{3.3}{5.0}(3r)$$ 1

$$r = 0.61\Omega$$ 1

(c) (i) Reading on voltmeter in circuit P = 1.5 V 1

(ii) Resistance in circuit Q = $5.0 + 3(0.606) = 6.818\ \Omega$ 1
New current = $1.5 / 6.818 = 0.22$ A 1

(d) Thermistor. 1

6 (a) (i) $T = e^{-2kd}$

$$\Rightarrow d = -\frac{\ln T}{2k}$$

For $U - E = 6.0$ eV,

$$k = \sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$$ 1

$$= \sqrt{\frac{8\pi^2(9.11\times10^{-31})(6.0\times1.60\times10^{-19})}{(6.63\times10^{-34})^2}}$$

$k = 1.253\times10^{10}$ m^{-1}

From eqn: $d = -\frac{\ln(0.0001)}{2(1.253\times10^{10})}$

$d = 0.368$ nm 1

(ii) **Method One:**

$$\frac{T_2}{T_1} = \frac{e^{-2kd_2}}{e^{-2kd_1}} = e^{-2kd_2+2kd_1} = e^{0.02kd_1}$$ 1

$= 1.0966$

$T_2 = 1.0966\ T_1$ 1

Percentage change = +9.66 %

Method Two:

Step 1:

Find T_2

$T_2 = e^{-2k(0.99)d} = e^{-2(1.253\times10^{10})(0.99)(0.3675\times10^{-9})} = 1.0973\times10^{-4}$

Step 2:

$$\frac{\Delta T}{T}\times100 = \frac{T_2 - T_1}{T_1}\times100 = \frac{1.0973\times10^{-4} - 0.0001}{0.0001}\times100$$ 1

$= +9.73\%$ 1

A decrease in d will lead to an increase in T.

Note: Use of rounded up intermediate values, i.e d or k in calculation will lead to a very different final answer as we are dealing with exponential here.

(b) As the STM is scanned across the sample surface with a fixed vertical position, the values of d changes due to the changes in height of the sample surface. 1

Hence the transmission coefficient T changes and the STM registers a change in the tunnelling current output which at each location would map a value of the tunnelling current and the entire data set would trace the sample topography. 1

7 (a) An extremely low/negligible resistance path is connected across the terminals. 1

(b) (i) The rotating disc cuts the **magnetic flux** and by Faraday's law, an **e.m.f. that is proportional to the rate of cutting of the flux** will be induced across the rim and axle of the plate. 1

Increasing the speed of rotation increases the rate of cutting of the flux and hence induces an increasing e.m.f. across the disc. 1

(ii) d.c 1

(iii) To study the properties of matter under extreme conditions/ as an electromagnetic gun to project small masses at high velocities/ to study the problem of re-entry of missiles into the atmosphere. (any 2) 2

(c) (i) Charge = Area under the *I*-*t* graph 1

$$=\frac{1}{2}\left(1.65\times10^{6}\times1.1\right)+\frac{1}{2}\left(1.65+0.2\right)\times10^{6}\times(3-1.1)+\frac{1}{2}\left(0.2\times10^{6}\times1.0\right)$$ 1

$= 2.77 \times 10^{6}$ C 1

Acceptable range : 2.4 – 3.1 MC

(ii) Max Power = $I_{\max}^{2}R$ =$(1.65 \times 10^{6})^{2} \times (1.2 \times 10^{-4}) = 3.3 \times 10^{8}$ W 1

(d) Units of *k* = Units of $\dfrac{V}{r^{2}B}$

= Units of $\dfrac{VA}{r^{2}\Phi}$ (where A is area and Φ is magnetic flux) 1

= Units of $\dfrac{V}{Vt}$ (since units of r^2 = units of A) 1

= s^{-1} 1

Possible quantity is frequency or angular frequency.

(e) (i) electrical energy from the circuit is converted to kinetic energy of the rotating disc. 1

(ii) kinetic energy of the rotating disc is converted into electrical energy of the induced current. 1