H2 PHYSICS

Exam papers with worked solutions

(Selected from Top JC)

SET E

PAPER 1

ANSWER

Compiled by

THE PHYSICS CAFE

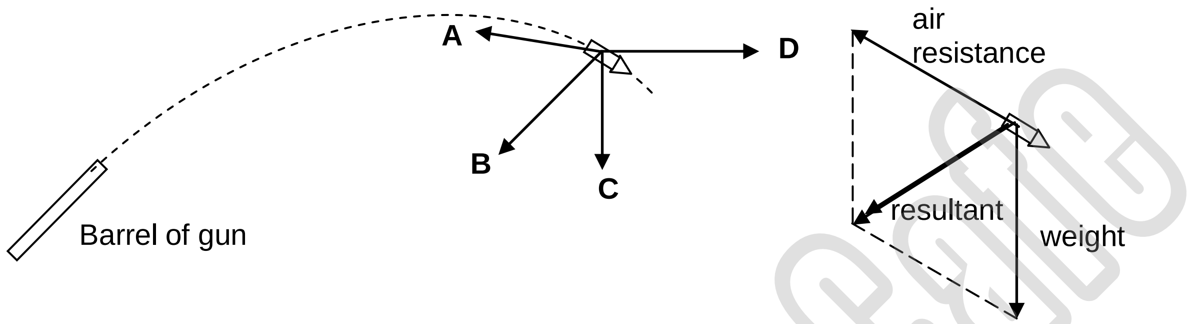
1C Volume of metre rule = L x B x H = 100 cm x 3 cm x 0.5 cm = 150 cm^3

2D $(d_1 - d_2) = ((64-47) \pm (1+2))$ mm = 17 ± 3 mm

% uncertainty = $\frac{3}{17} x100 = 17.6\% = 18\%$

The percentage error is calculated from the precision of the measurements; hence it is a random error.

3B



4C Area bounded by the ***a-t*** graph give the change in velocity. Particle accelerates from t=0 to point B, accelerated in the opposite direction (slow down) after point B, then accelerate in the original direction till C before decelerating from C to D. Hence, particle's velocity is maximum at C.

5C Since increase in kinetic energy is constant at each gap,

Δke= constant $= \frac{1}{2}m(v_4^2 - v_3^2) = \frac{1}{2}m(v_3^2 - v_2^2) = \frac{1}{2}m(v_2^2 - v_1^2)$

or $(v_4^2 - v_3^2) = (v_3^2 - v_2^2) = (v_2^2 - v_1^2)$

$(v_4 - v_3)(v_4 + v_3) = (v_3 - v_2)(v_3 + v_2) = (v_2 - v_1)(v_2 + v_1)$

Since $v_4 > v_3 > v_2 > v_1$,

then, $(v_4 + v_3) > (v_3 + v_2) > (v_2 + v_1)$

Hence, $(v_4 - v_3) < (v_3 - v_2) < (v_2 - v_1)$.

In other words, the increase in speed gets smaller as the particle moves from one cylinder to the next.

6B To keep the weight of 100 N stationary, the rim of the wheel must exert a force of (100- 20) N on the rope.

Velocity of rim of wheel = distance / time = circumference x 50 rev s^{-1} = 0.30 x 50 = 15 m s^{-1}

Power = Force x velocity = 80 N x 15 = 1200 W = 1.2 kW

7B By conservation of total mechanical energy

$KE_i + PE_i = KE_f + PE_f$

$0 + PE_i = KE_f + PE_f$

$KE_f = -(PE_f - PE_i)$

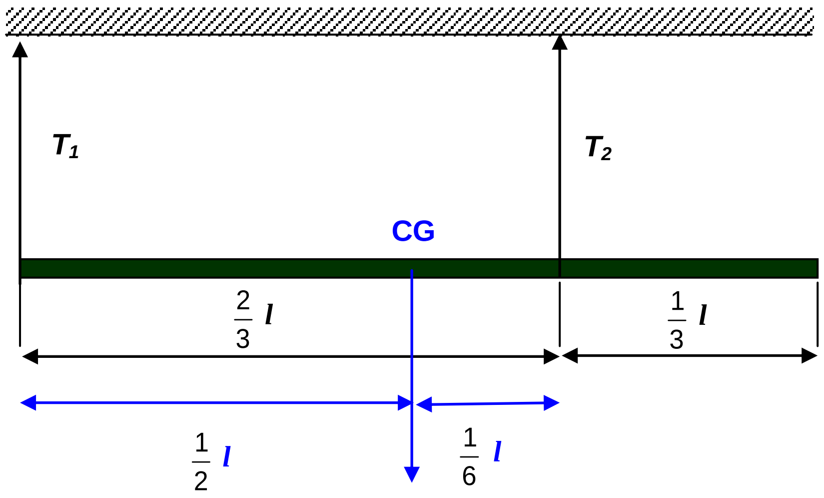
$= -\left[(PE_f - PE_i)_x - (PE_f - PE_i)_Y\right]$

$= -\left[(4.0x9.81x2.0\sin 30^o)_x - (5.0x9.81x2.0)_Y\right]$

= 59 J

8A Take moments about the CG of the beam,

$T_1 x \frac{1}{2} l = T_2 x \frac{1}{6} l$ **Hence, $T_1 / T_2 = 1/3$**



9A As object accelerates under the constant forward force, its velocity increases. The retarding force increases with the velocity until the magnitude of retarding force equals the magnitude of the forward force. Resultant force is zero and the velocity stops increasing and remains at a maximum value.

10D When raindrop falls at steady speed, weight mg = retardig force kv.

$\therefore \ v=\frac{mg}{k}$.

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{mg}{k}\right)^2 = \frac{m^3g^2}{2k^2}$$

11*D* By Newton's 3rd law,

magnitude of force on P by Q = magnitude of force on Q by P = F

By Newton's 2nd law, net force on Q, F = $m_Q a$

$\therefore$ acceleration of Q = $\frac{F}{m_Q} = \frac{m_P a}{m_Q}$ where F = $m_P a$

12D Final system momentum P_f = (10 -2) N s = 8 Ns to the right.
Initial system momentum P_i = 22 + p_y = 8 Ns to the right.
Hence, p_y = - 14 Ns (to the left).

13B $v=r\omega \Rightarrow \omega=\frac{v}{r}$. Since v is constant, $\omega \propto \frac{1}{r}$.

14C Keplar's law: $T_A^2 \propto r_A^3$

and $T_B^2 \propto r_B^3$.

Hence, $T_B = T_A\left(\frac{r_A}{r_B}\right)^{\frac{3}{2}}$

15*A* change in gravitational potential energy $\Delta U = m\Delta\phi$

$$= 50\,(-60-(-20))\times10^{6} = -2000 \text{ MJ}$$

Negative sign indicates a loss of gpe. The mass moves closer to the Earth

16B Process 1 : gas is heated at constant volume $\Rightarrow$ ΔQ increases, ΔW is zero
Hence, by first law of Thermodynamics, $\Delta U = \Delta Q + \Delta W > 0$. Internal energy increases.

Process 2: gas is compressed at constant pressure.
Ideal gas equation: PV = nRT. At constant pressure, P is constant;
and compression means volume V decreases. So, PV decreases and tempreature T decreases.
Since for ideal gas, internal energy U is proportional to T, U decreases.

17D Ideal gas equation: $P_1V_1 = nRT_1$

Rewriting: $P_1 = nRT_1\dfrac{1}{V_1}$ where nRT_1 is the gradient of the T_1 graph.

Similarly, $P_2 = nRT_2\dfrac{1}{V_2}$ where nRT_2 is the gradient of the T_2 graph.

Ratio of $\dfrac{\text{mean kinetic energy of molecules at } T_2}{\text{mean kinetic energy of molecules at } T_1} = \dfrac{\frac{3}{2}kT_2^2}{\frac{3}{2}kT_1^2}$

$$= \frac{T_1^2}{T_2^2} = \frac{\left(\text{gradient of } P_2 \text{ against } \frac{1}{V_2} \text{ graph}\right)^2}{\left(\text{gradient of } P_1 \text{ against } \frac{1}{V_1} \text{ graph}\right)^2} = \frac{\frac{4}{1}}{\frac{1}{4}} = 16:1$$

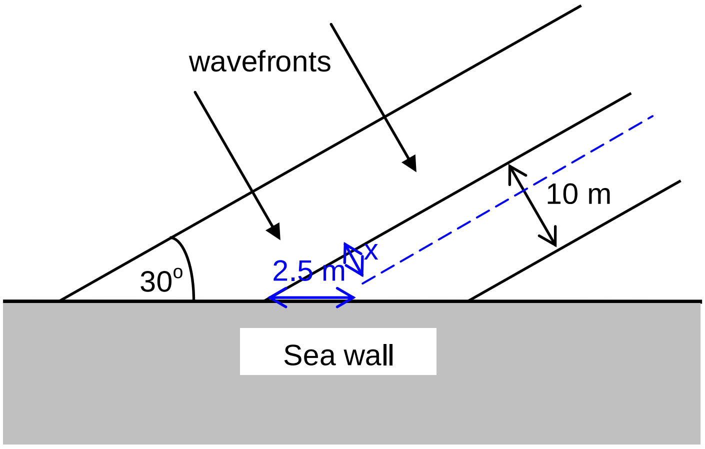
18D The definition of SHM is: to and from motion about an equilibrium position such that:
(1) the acceleration is proportional to displacement from the equilibirum position, and
(2) the direction of acceleration is opposite to the displacement
(i.e. directed towards the equilibrium position).
The displacement in general is given by $x = x_o \sin(\omega t - \phi)$ where ϕ is a phase constant.
The displacement may be given by $x = x_o \sin(\omega t)$ if ϕ is zero, but is NOT always the case.

19B At the closed end, air molecules cannot vibrate, hence it is a Node with zero amplitude.
The surrounding molecules vibrate towards the Node, hence, pressure variation is maximum

At the opened end, air molecules have maximum displacement Δx, the pressure variation is minimum, i.e. it is always at the average pressure.

20C Object P experiences lower degree of damping compared to object Q. Hence, the frequency response curve of object P is higher in amplitude and resonance occurs at a higher frequency than the frequency response curve of object Q.

21A



Path difference x = 2.55 sin 30^o = 1.25 m

Phase difference $\phi = 2\pi \frac{x}{\lambda} = 2\pi \frac{1.25}{10} = \frac{\pi}{4} = 45^o$

22D For wave length of 650 nm, fringe separation $\Delta x = \frac{\lambda D}{d} = \frac{650x10^{-9}x1.00}{0.20x10^{-3}} = 3.25\ mm.$

At P, 13 mm away from centre of fringe system, there will be $\frac{13}{3.25} = 4$ fringes.

Hence, P is a position of maximum intensity.

For wavelength of 400 nm, fringe separation = 2.00 mm.

At P, 13 mm away from the centre of fringe system, there will be $\frac{13}{2} = 6.5$ fringes.

Hence, P is a position of minimum intensity.

23*A* Total current = current due to electrons I_e + current due to ions I_i.

$I_i = 8.16x10^{-3} - (2.58x10^{16}x1.6x10^{-19}) = 4.032x10^{-3}A$

Number of ions per unit time = $4.03x10^{-3} / 3.2x10^{-19} = 1.26x10^{16}s^{-1}$.

24*B* P.d. across XY, $V_{XY} = \frac{ER}{R+2r} \propto L$

E.m.f ε=p.d. across balance length of $\frac{L}{3} = \frac{V_{XY}}{3} = \frac{ER}{3(R+2r)}$.

25D Current delivered by generator $I=\frac{P}{V}$.

Power dissipated in cable resistance $P_{loss}=I^2R=\left(\frac{P}{V}\right)^2R$

Hence, power delivered to factory = P - $P_{loss}=P-\left(\frac{P}{V}\right)^2R$.

26C Current across the 3 kΩ resistor $I_3=\frac{3v}{3k\Omega}=1.0$ mA.

By Kirchoff's junction theorem, $I_2=I_1+1.0=0.5+1.0=1.5$ mA.

27*A* $E=-\frac{dV}{dr}=-\left(\frac{70-30}{2.0x10^{-3}}\right)=-20$ kN C^{-1}. Direction is towards decreasing potential, i.e. to the right.

28*D* Net potential at the centre of the circle $V_{net}=\frac{1}{4\pi\varepsilon_o r}(4Q-2Q)=+\frac{Q}{2\pi\varepsilon_o r}$.

Work done by external agent to bring a positive charge of magnitude Q to centre of circle,

$W=V_{net}Q=+\frac{Q}{2\pi\varepsilon_o r}Q=+\frac{Q^2}{2\pi\varepsilon_o r}$.

29*A* Since the magnetic force is always perpendicular to the plane containing B and v vector, the path of the charge is circular.

Centripetal force of charge = magnetic force

$m\frac{v^2}{r}=Bqv$

Radius $r=\frac{v}{B}\frac{m}{q}$. $\Rightarrow r\propto\frac{m}{q}$ for a given B and v.

30C The magnitude of e.m.f induced is directly proportional to the rate of change of magnetic flux linkage, which is proportional to the rate of cutting of magnetic flux by the falling coil. Since the coil drops from rest, its speed increases as it falls vertically, so the rate of cutting is largest in diagram C.

31B Moment due to couple = Fd = NBILd = $20x0.010x5.0x10^{-3}x8.0x10^{-3}x8.0x10^{-3}=6.4\ x10^{-8}$ Nm.

32C For sinusoidal a.c., average power $\langle P\rangle=\left\langle\frac{V^2}{R}\right\rangle=\frac{1}{R}\left(\frac{V_o^2}{2}\right)=\frac{V_o^2}{2R}=W$

For square waveform a.c., average power $\langle P\rangle=\left\langle\frac{V^2}{R}\right\rangle=\frac{V_o^2}{R}=2W$.

33D Momentum of electromagnetic wave of wavelength λ is given by $p=\frac{h}{\lambda}$.

For the same electromagnetic wave of wavelength λ, momentum remained the same.

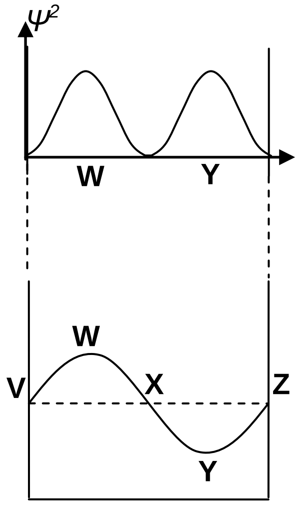
34C Number of electrons emitted per second $\frac{N_e}{t} = \frac{\text{current}}{\text{charge of an electron}} = \frac{2.0x10^{-6}}{1.60x10^{-19}} = 1.25x10^{13}$.

Since efficiency of emission of electrons by radiation is 2 %,

number of photons incident on the metal plate is $\frac{N_p}{t} = \frac{1}{0.02}\frac{N_e}{t} = 6.25x10^{14}$

Inensity = $\frac{N_p}{t}\frac{E}{A} = 6.25x10^{14}x\frac{6.63x10^{-34}x3x10^{8}}{400x10^{-9}x5.0x10^{-6}} = 62$ W m^{-2}.

35A From the Ψ^2 graph, the electron has the highest probability of being found at points W and Y.



36C The shortest wavelength of x-ray in the continuous spectrum $\lambda_{min} = \frac{hc}{eV}$.

When the accelerating potential is increased, λ_{min} decreases.

The wavelength λ_2 is due to transition between energy levels of the target atoms and is unaffected by the accelerating potential.

37A Impurities in semiconductor increases the conductivity and decreases the resistance.

38D E + ${}^{2}_{1}H \rightarrow {}^{1}_{1}H + {}^{1}_{0}n$

E = $\Delta mc^2 = (1.0086 + 1.0097 - 2.0150)x1.66x10^{-27}x(3x10^{8})^2 = 4.9302x10^{-13}J$

Convert to MeV, E = $4.9302x10^{-13}/1.6x10^{-13} = 3.08$ MeV

39D Excitation must be from ground state to the higher of the two excited states. Given that spontaneous emission gives infra-red radiation and stimulated emission gives red light, the energy level difference for spontaneous emission must be smaller than the energy level difference for stimulated emission because infra-red has longer wavelength compared to red radiation. Hence, answer is D.

40A Decay rate A = $\lambda N = \frac{\ln 2}{t_{\frac{1}{2}}}N$ where N is proportional to the number of moles of raioactive nuclei.