2004 HKAL Physics MC Suggested Solution

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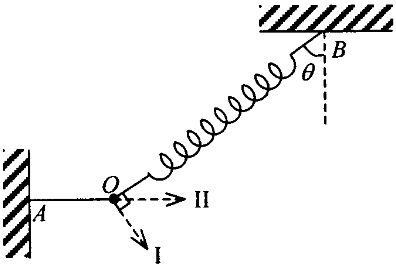


Let F_s : force acting on the object Q by the spring

F_t: force on the object Q by the thread

W: weight of the object Q

Vertical balance: $F_s\cos\theta = W$ …………(i)

Horizontal balance: $F_s\sin\theta = F_t$ …………(ii)

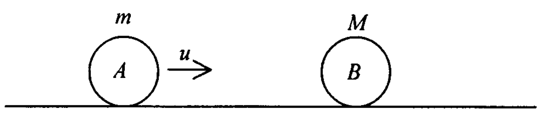
Note that the thread does not take part in the vertical balance. At the moment when the thread is cut, (i) is still correct, but (ii) is not.

The acceleration is horizontal (to the right) and the magnitude of acceleration is $a = F_s\sin\theta/m$

From (i), $a = W\tan\theta/m = g\tan\theta$

(D)

2.



The collision is elastic (KE is conserved)

We know that

	After collision
(I) m=M	m stops, M moves at the initial speed of m.
(II) m << M	m rebounds in the reverse direction, M moves forward
(III) m >>M	Both m and M move forward. M must move faster than m (same speed occurs only when the collision is completely inelastic.)

In case (I), the kinetic energy of B is the greatest, because all the initial KE of A has been transferred to B then.

In (II), the momentum of B is the greatest.

$mu = mv_A + mv_B$

$mv_B = mu - mv_A$

The momentum of B is the greatest when mv_A is the most negative.

The correct answer is therefore (C). (In (III), the speed of B is the greatest).

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3. We know that an object is dropped at P when the bullet is fired, they will meet at a point below P.

Time for the bullet to go to a point below P, $t = 40\sin\theta/v_x = 40\sin\theta/50\sin\theta = 0.8$ s

Therefore, the distance below P when the bullet is vertically below P = $\frac{1}{2}gt^2 = \frac{1}{2}(10)(0.8^2) = 3.2$ m

(A)

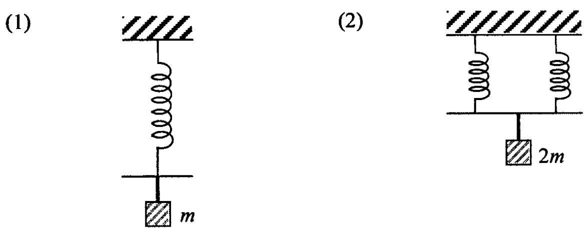
4. At the top, $mg = m\frac{v_t^2}{R}$. Hence, $v_t = \sqrt{gR}$

By conservation of energy $\frac{1}{2}mv^2 = \frac{1}{2}mv_t^2 + mg(2R)$

$$v^2 = gR + 4gR = 5gR$$

$$v = \sqrt{5gR} = \sqrt{5\times1.6\times0.5} = 2.0ms^{-1} \quad \text{(C)}$$

5.



In (1), the spring can be regarded as a series combination of two springs of each having the half length. The total extension is e, so the extension of one smaller spring is e/2. (mg causes an extension e/2).

In (2), the weight 2mg is shared by the two smaller springs. Each takes the load mg, hence the extension produced is still e/2. (C)

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6. In SHM, a = -kx (k is a positive constant). F = ma. The answer is (B).

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7. $g = \frac{GM}{R^2}$. Now, M is 3 times larger and R is 2 times larger, so g is $\frac{3}{2^2} = \frac{3}{4}$ larger, i.e. 7.5 ms^{-2} (A)

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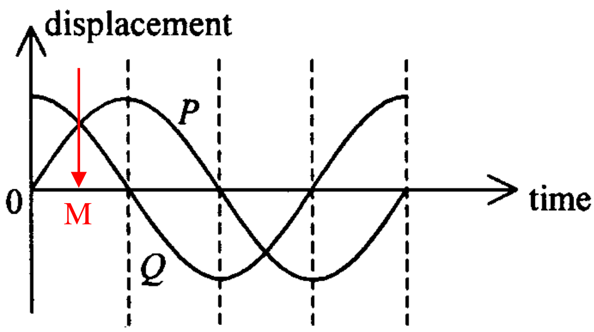
8. When a rigid disk rotates about its central axis, each point of it has the velocity

$v = \omega r$. ω is a constant, so $v \propto r$

If discrete points rotate about the same central object, the centripetal force required by each of them must be provided by its own gravitational attraction by the central object.

$m\frac{v^2}{r} = G\frac{M}{r^2}$. Hence $v \propto \frac{1}{\sqrt{r}}$ (B)

9.



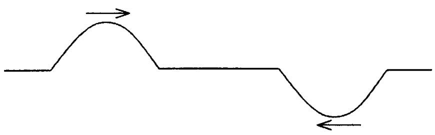
At first, sketch the resultant wave.

It is quite obvious that a peak of the resultant wave will appear at the time M indicated in the diagram.

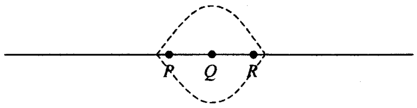
The resultant wave leads P by 1/8 of a cycle, i.e. π/4 or 45^0. (B)

10.

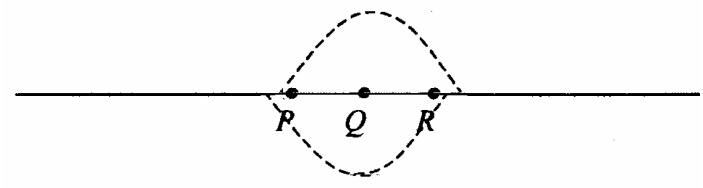
(1)



(2)



(3)



The two waveforms at the instant just after (2) is shown in (3). The resultant waveforms at P, Q and R are downward, zero and upward respectively. In other words, in (2), P is moving downward, Q is stationary and R is moving upward. (D)

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11. Young's double slits

$d\sin\theta = m\lambda$. Since $\sin\theta = \dfrac{x}{D}$, so $x_m = m\dfrac{\lambda D}{d}$. Thus, fringe separation $\Delta x = \dfrac{\lambda D}{d}$

(1) Longer wavelength → fringe separation increases

(2) Greater slit separation (d) → fringe separation decreases

(3) Larger slit width → less diffraction (reduce the width of each bright fringes, but not the fringe separation).

(A)

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12. Red light has a smaller degree of refraction than blue light. P is red, Q is blue.

L diverges light, so it may be a concave lens.

Since red light(P) has a smaller index of refraction, so in glass it moves faster than blue light.(v = c/n)

(B)

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13. At the closed end, velocity is a node while pressure is an antinode.

The fundamental frequency of the air column in the tube **may be** equal to the frequency of the tuning fork. The latter may also be equal to the overtones of the tube.

(D)

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14. Pressure P = ρgh

Total weight of air acting on the ground = $P(4\pi R^2) = Mg$

$M = P(4\pi R^2)/g = 100 \times 10^3 \times 4\pi \times (6400 \times 10^3)^2/10 = 5 \times 10^{18}$ kg

(C)

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15. A and B are acted on by the same electrostatic repulsion, and so it is an internal force.

The system is in equilibrium, the moment about any point must be zero.

We calculate the moment about O:

The tensions do not produce any moment. The electrostatic force is an internal force, we need not to calculate its moment.

Moment produced by the weight of A = Moment produced by the weight of B

$m_A g\, L\sin 30^0 = m_B g L\sin 60^0$ Hence, $m_A : m_B = \sin 60^0 : \sin 30^0 = \sqrt{3} : 1$ (A)

16. Potential is a scalar, so we just sum the potential due to individual charges.

$V \propto \frac{q}{r}$ Q is changed to –2Q, r is changed to r/2, so V is changed to –4V

The total potential is therefore V +(-4V) = -3V. (B)

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17. The parallel-plate capacitor is connected to the battery, so the p.d. between the plates remains constant. E = V/d. V is a constant, d is increased, so E is decreased.
The p.d. between P and A = E(distance between P and A). E is reduced, so V_{PA} is reduced too.
Energy stored in the capacitor is QV/2 . Q decreases (E is proportional to Q), so the energy decreases. (B)

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18. The trajectory may be an ellipse, a parabola or a hyperbola, depending on the total energy of the moving object (or whether the orbit is closed or not).
The force is inverse- squared, so the acceleration at B is smaller that that at A.
At B. the KE is smaller (angular momentum $mvr_{\perp}$ = constant)
The force is attractive and the P.E.. is taken to be zero at infinity, so $V \propto -\frac{1}{r}$ (D)

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19. An reverse-biased diode has a very large internal resistance. To measure such a large resistance, the circuit in (D) is most appropriate.
Circuit D: The ammeter does measure the current passing through the diode, but the voltmeter in fact measures the total p.d. across the series combination of the ammeter and the diode. However, the resistance of the diode is much larger than that of the ammeter, so there is little error in taking the reading in voltmeter as the p.d. across the diode.

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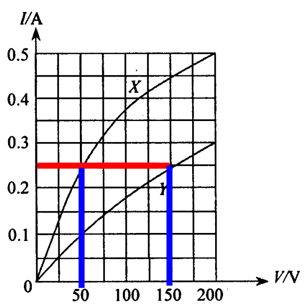
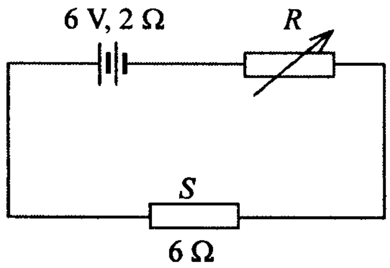
20. S is infinitely large, so we can remove it.
Resistance across AC = resistance across AB + resistance across BC
= resistance across AB + resistance across DC
=1 kΩ + 2.5 kΩ
=3.5kΩ (B)

21.



By inspection, when the current is 0.25A, the p.d. across X and Y are 50 V and 150 V respectively.
50V + 150V = 200V.
So the actual current in the circuit is 0.25 A
P = VI
P_X = 50(0.25) = 12.5 W
P_Y = (150)(0.25) = 37.5 W (A)

22.



Power dissipated in S = $I^2(6\Omega)$

Current I = $6V/(2\Omega + R + 6\Omega)$

The largest the current, the largest power in S.

To achieve the largest current, the value of R should be zero.

(A)

23.

The full-scale-deflecton current is not changed after the connection of the multiplier

f.s.d current = 100 μA, f.s.d.V = 5V

Internal resistance of the meter = f.s.d.V/f.s.d.I = $5/100 \times 10^{-6}$ = 50 kΩ (B)

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24. $V = \frac{Q}{4\pi\varepsilon_o R}$ $\because V = \frac{Q}{C}$ $\therefore Capacitance\ C = 4\pi\varepsilon_o R$

Sphere A has a smaller radius, so the potential at its surface is higher (A is correct)

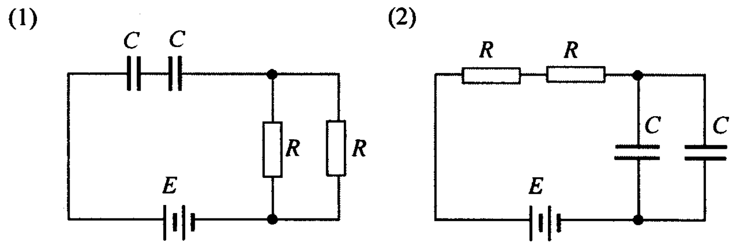
Sphere B has a larger capacitance, so it has a larger capacitance (B is correct)

Energy stored $E = \frac{1}{2}QV \propto \frac{1}{R}$. Sphere A stores more energy (C is incorrect)

Sphere A has a higher potential so its charge will flow to B if a wire is connected between them. (D is correct)

(C)

25.



When the steady state is achieved, the current will drop to zero.

In (1) , the voltage across each C = E/2

Total Energy = $2[\frac{1}{2}C(\frac{E}{2})^2] = \frac{1}{4}CE^2$

In (2), the voltage across each C = E

Total energy = $2(\frac{1}{2}CE^2) = CE^2$

The required ratio is 1/4 : 1 or 1: 4 (D)

26.

Hall voltage $V_H = \frac{BI}{net}$

The polarity of the Hall voltage depends on the sign of the charge carriers.
The number density of free electrons (n) can be found if all other things are known.
A Hall probe is an instrument for measuring an unknown B-field due to a d.c. only.
To an a.c., the field changes with time, a Hall probe is incapable to take any measurement.
(B)

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27. The ratio relationship of a transformer

$\frac{V_S}{V_P} = \frac{N_S}{N_P}$ is valid only when (I) there is no flux leakage (II) there are no ohmic potential drop across the two windings.

(1) The flux leakage is negligible (correct)
(2) The energy loss in the primary coil is negligible (it is equivalent to say that the internal resistance of the primary coil is negligible) (correct)
(3) The secondary coil is on open circuit. (Open circuit ⟶ no secondary current ⟶ no IR drop in the secondary coil) (correct)

(D)

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28. The magnetic field produced by a long solenoid is approximately constant at the central portion inside it. At one end, its field is only one-half of that in the middle.
The magnetic field inside a long solenoid is independent of its cross-sectional area.
(D)

29.

Magnetic force $F = Bil = \frac{\mu_o Ii}{2\pi R}$

Force acting on R by P = $\frac{1(2)}{2}F$ = F (attract)

Force acting on R by Q = $\frac{(2)(2)}{1}F$ = 4F (repel)

The net force is therefore 3F (D)

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30. R, L and C are connected in series, the current through them must be the same at all time
C and L store, but not dissipate energy.

Energy in C $\propto V_C^2$, energy in L $\propto I^2$. Some energy is transferred to and fro between L and C.

(D)

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31. The rms of a full-wave a.c. = $\frac{I_o}{\sqrt{2}}$

Average power of a full-wave a.c. = $\frac{I_o^2 R}{2}$

The average power of a half wave is only on-half of the above value, i.e. $\frac{I_o^2 R}{4}$ ……..(1)

By definition (RMS I is the current that give the same average power), (1) is equal to the

$I_{rms}^2 R$ …………(2)

Comparing (1) and (2), we find $I_{rms} = \frac{I_o}{2}$

(C)

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32. $KE_{max} = hf - \phi$

Lower frequency, lower maximum kinetic energy

Intensity = nhf

When yellow light is used, the frequency is reduced, the number of photons is increased, the number of electrons ejected is increased as well.

(C)

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33. $E_n = -\frac{13.6}{n^2}$

First excited state, n = 2, the energy is –3.4eV

The energy for ionizing it is 0-(-3.4) = 3.4 eV (A)

34.(1) Hot liquid and solid produce continuous spectra

(2) The dark lines are produced by the absorption of the elements which are **present** in the gas envelope surrounding the sun.

(3) The dark line are due to the absorption in the cooler gas surrounding the sun, not the atmosphere of the earth

(A)

35.

$C = C_o e^{kt}$

$\log C = \log C_0 + (\log e)kt$, the graph of plotting logC against t is linear.

Value will drop by one-half after one half-life $t_{1/2} = \ln 2/k$

Let T be the time of one year

C for a certain year $C = C_o e^{kt}$ ………(i)

C for the previous year $C = C_o e^{k(t-T)}$ ……….(ii)

(i)/(ii) e^{kT}, which is independent of t.

(D)

36. From relevant formulae, we know energy = QV, energy = Fe, energy = PV
(C)

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37. PV is proportional to temperature
At X, PV = 1(4) = 4 units
At Y, PV = (3)(2) = 6 units
AT Z, PV = (5)(1) = 5 units
Hence, temperature at Y . temperature at X > temperature at X
(A)

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38. Advantages of employing negative feedback :
(i) voltage gain is independent of the parameter of the amplifier, it can be set by the user
(ii) the voltage gain is more stable and not unrealistically too large.
(iii) avoid distortion of the signal being amplified.
(1) and (2) are correct, but not (3)
Even though negative feedback is used, distortion may still occur. It is no guarantee that distortion does not occur if negative feedback is used.
(B)

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39. Collector current I_C = (6-3)/1kΩ = 3mA
Base current I_B = 3mA/50 = 6 × 10^{-5} A
P.d. across R_B = 6 – 0.6 = 5.4 V
R_B = 5.4/6 × 10^{-5} = 90 kΩ
(C)

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40. It is an inverting amplifier with voltage gain A = $-\frac{R_f}{R_i}$
The output voltage V_o satisfies $-9V \le V_o \le 9V$
Saturation occurs if gain × input voltage does not lie within the range $\pm 9V$.
When R_i = 1 kΩ, R_f = 10kΩ, the gain is the largest among the four options. The output voltage then best resembles a square wave.
(B)

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41. Time constant of a RC circuit = RC. Hence, unit of C = unit of time/unit of R [F = sΩ^{-1}]
Time constant of an LR circuit = L/R . Hence, unit of L = unit of R × unit of time [H = Ωs]
Faraday law of induction V = $-\frac{d\Phi}{dt}$. Hence, unit of flux = unit of voltage × unit of time [Wb = Vs]
(B)

42.

Activity A = $-\frac{dN}{dt}$

Since one day << half life, so the activity is essentially a constant over a period of one day.

Number of nuclei decayed within one day = A x 1day = $1.0 \times 10^{6} \times 24 \times 60 \times 60 = 8.6 \times 10^{10}$

(C)

43.

Corrected count rate = GM reading – background radiation

(1) A GM tube is designed such that most β particles can pass through its mica window.

(2) The β particles are emitted in all directions. The GM tube only register a fraction of them.

(3) Within a "dead time', two separate particles cannot be distinguished, they are miscounted as one particle.

(C)

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44. (1) It is a nuclear fusion process.

(2) Mass is equivalent to energy. The total mass of the two deuterons is greater than the total mass of the helium-3 and X.

(3) X is a neutron ($^{1}_{0}n$).

(A)

45.

(1) A moving-coil voltmeter has a certain internal resistance. A circuit being connected to it will unavoidably be affected.

(2) A thermometer will absorb some energy from the hot water. Hence, the temperature of the hot water will be lowered (but you intention is to measure the original temperature!)

(3) A spring balance will not affect the weight measured.

(C)
