2022 VJC Prelim H2 P1 Suggested solution

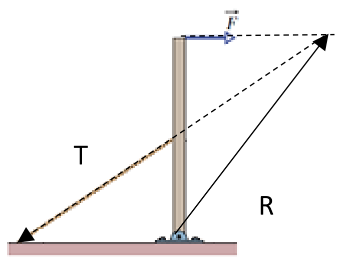
Qn	Ans	Qn	Ans	Qn	Ans	Qn	Ans	Qn	Ans	Qn	Ans
1	D	6	D	11	A	16	A	21	C	26	D
2	B	7	B	12	A	17	C	22	A	27	D
3	B	8	B	13	D	18	A	23	C	28	A
4	A	9	B	14	D	19	B	24	B	29	C
5	C	10	B	15	B	20	D	25	D	30	D

1. **Ans: D**

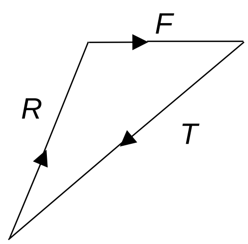
Base units of self-inductance = $\frac{V}{As^{-1}} = \left(\frac{W}{A}\right)\frac{1}{As^{-1}} = \left(\frac{kgm^2s^{-2}}{As}\right)\frac{1}{As^{-1}} = kgm^2s^{-2}A^{-2}$

2. **Ans: B**

For the rod to be in equilibrium, the 3 forces acting on the rod should extrapolate and intercept at a common point.



The 3 forces should form a vector triangle with the forces pointing in a single direction.



3. **Ans: B**

Total momentum = $2Mv - Mv = Mv$

Option A is a correct statement (so don't choose it). The spheres cannot come to rest at the same time as that will give a total momentum of 0 and not *Mv*.

Option C is a correct statement. For total momentum to be conserved, the change in momentum of A and B must be equal and opposite.

Option D is a correct statement. Newton's 3^{rd} law.

4. **Ans: A**

Work done by F on object = area under the graph = $K + L + M$
Work done against frictional force = $L + M$ (friction is constant, = 5 N)

Net work done by F = work done by F – work done against frictional force
= $K + L + M - (L + M)$
= K
= gain in kinetic energy of the object

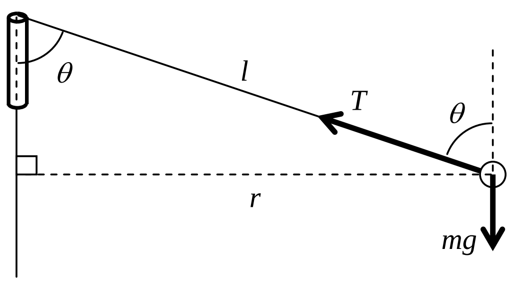
5. **Ans: C**

Output power, $P_o = 0.25P_i = (0.25)(10) = 2.5$ W

$$P_o = \frac{E}{t}$$

$$t = \frac{E}{P_o} = \frac{mgh}{P_o} = \frac{(20)(0.50)}{2.5} = 4.0 \text{ s}$$

6. **Ans: D**



For circular motion,

Horizontally, $T\sin\theta = mr\omega^2$ where T = tension in string
θ = angle between string and vertical.
m = mass of bob
r = radius of circular motion.

$$\Rightarrow T\sin\theta = m\left(l\sin\theta\right)\left(2\pi f\right)^2$$

$$l = \frac{T}{4\pi^2 m f^2}$$

$$l \propto \frac{1}{f^2}$$

Note: T is constant as it is equal to the weight of the brass weights.

7. **Ans: B**

Magnitude of gravitational acceleration = potential gradient

At the height of 370 km, $g = \dfrac{[-617.0-(-649.6)]\times 10^3}{[380-360]\times 10^3} = 1.63\,\text{m s}^{-1}$

8. **Ans: B**

At a *higher* orbit, r is *increased,*

Gravitational force *decreases* $F_G = \dfrac{GMm}{r^2}$

Gravitational potential energy *increases* $U = -\dfrac{GMm}{r}$

Linear speed *decreases* $\dfrac{GMm}{r^2} = \dfrac{mv^2}{r} \Rightarrow v = \sqrt{\dfrac{GM}{r}}$

Kinetic energy *decreases* $\dfrac{GMm}{r^2} = \dfrac{mv^2}{r} \Rightarrow \dfrac{1}{2}mv^2 = \dfrac{GMm}{2r}$

9. **Ans: B**

Heat was removed from it at a constant rate when it was totally liquid, and when totally solid.

$$mc_{liquid}\left(\frac{\Delta T}{t}\right)_{liquid} = mc_{solid}\left(\frac{\Delta T}{t}\right)_{solid}$$

$$c_{liquid}\left(\frac{400-300}{100}\right)_{liquid} = c_{solid}\left(\frac{300-200}{50}\right)_{solid}$$

$$c_{liquid} = 2c_{solid}$$

10. **Ans: B**

$$C_{rms} = \sqrt{\frac{3RT}{M}} \propto \sqrt{T} \propto \sqrt{PV} \quad \text{since } PV = nRT$$

$$\frac{C_{rms2}}{C_{rms1}} = \sqrt{\frac{P_2V_2}{P_1V_1}} = \sqrt{\frac{2(2)}{1(1)}} = 2$$

11. **Ans: A**

At U, velocity is negative (negative gradient of x-t graph), acceleration is positive (since displacement is negative).
At Y, velocity is positive, acceleration is negative.

12. Ans: A

Max force = m a_{max} = m ω^2 x_0
= 20 x 10^{-3} $(3\pi)^2$ (6 x 10^{-3}) = 0.011 N

13. Ans: D

The peak of B occurs at t = 0, while the peak of A occurs one quarter of a cycle later. So A lags B by 90º.

14. Ans: D

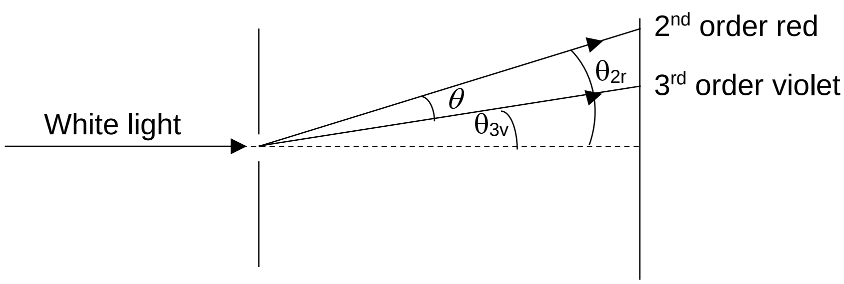
$v_{max} = \omega x_0$
$= 2\pi f\, x_0$
$= 2\pi \dfrac{v}{\lambda}\, x_0$
$= 2\pi \times \dfrac{4.0}{0.15} \times 0.030$
$= 5.0 \text{ m s}^{-1}$

15. Ans: B

High resolving power means objects close together will still be well resolved. To improve the resolving power, the Raleigh's criterion angle θ should be made smaller.

Since $\sin\theta = \dfrac{\lambda}{a}$, θ can be reduced by making a, the slit width, bigger.

16. Ans: A



For each order, red (longest wavelength) will diffract more than violet (shortest wavelength).

2nd and 3rd orders overlap means the 2nd order red diffracts more than 3rd order violet

Slit separation d = $\frac{1 \times 10^{-3}}{300}$ = 3.333 x 10^{-6} m

Using $\sin\theta = \frac{n\lambda}{d}$,

For red: $\sin\theta_{2r} = \frac{2 \times 700 \times 10^{-9}}{3.333 \times 10^{-6}}$

$\theta_{2r} = 24.8^o$

For violet: $\sin\theta_{3v} = \frac{3 \times 400 \times 10^{-9}}{3.333 \times 10^{-6}}$

$\theta_{3v} = 21.1^o$

$\therefore \theta = \theta_{2r} - \theta_{3v}$

= 24.8 – 21.1
= 3.7^o

17. Ans: C

The electric force on the positive charge is pointing in the direction of the E-field. So the external force exerted to move the charge is pointing in the opposite direction to the E-field.

Work done by external force, $W = F s \cos\theta = qEs \cos 0°$
$= (2.6 \times 10^{-8})(3.0 \times 10^{5})(4.0 \times 10^{-3})$
$= +3.1 \times 10^{-5}$ J

18. Ans: A

When the electron moves downward, its gravitational PE decreases. (The Earth's gravitational field is pointing vertically downward.)

The electron has negative charge, so it will accelerate towards the positive plate due to the downward electric force on it. Its gain in KE comes mostly from its loss of electric PE. So its electric PE decreases.

(H2 students can also reason this way: when a negative charge moves from a region of lower electric potential to another region of higher electric potential, its electric PE decreases.)

19. Ans B

With another identical lamp added parallel to X, the effective resistance across X is halved of its initial value. Total resistance in the circuit drops. By potential divider principle, potential difference across X is smaller and across Y is larger. Brightness of the lamp depends on the power ($P=V^2/R$) delivered to lamp, hence X is less bright and Y is brighter.

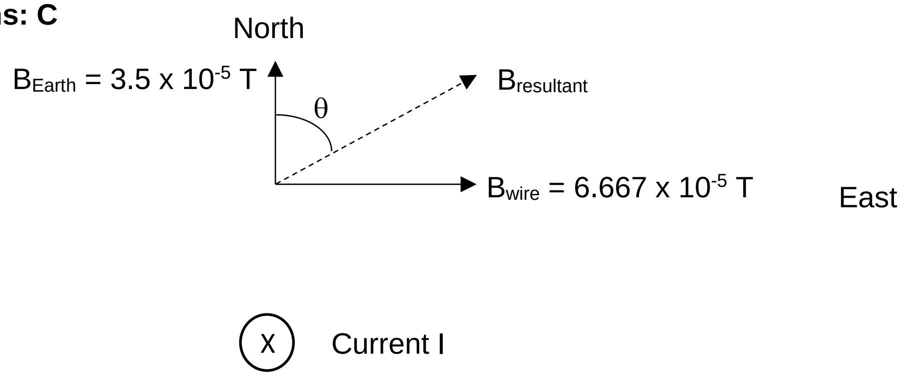
20. **Ans D**

When switch is open,
V_{PQ} = (0.70/1.0) x 2.0 V = 1.4 V
□ E = 1. 4 V

When switch is closed,
V_{PQ} = (0.50/1.0) x 2.0 V = 1.0 V

By potential divider principle,
p.d. across 2.0 Ω□, $V_{2.0}$□ = (2.0/(2.0+r)) x 1. 4 V
1.0 = (2.0/(2.0+r)) x 1. 4
□ r = 0.80 Ω

21. **Ans: C**



By right hand grip rule, magnetic field produced by wire at compass, B_{wire}, points to east.

$$B_{wire} = \frac{\mu_0 I}{2\pi r}$$

$$= \frac{4\pi \times 10^{-7} \times 3.0}{2\pi \times 9 \times 10^{-3}}$$

$= 6.667 \times 10^{-5}$ T

$$\tan\theta = \frac{B_{wire}}{B_{Earth}}$$

$$\theta = \tan^{-1}\frac{6.667}{3.5}$$

$= 62^{o}$

22. **Ans: A**

Going through crossed fields undeviated: $F_E = F_B$

$$qE = B_1qv$$

$$\text{Speed of particle, } v = \frac{E}{B_1}$$

Going through 2[nd] field, undergo circular motion of diameter 60 cm:

$$\frac{mv^2}{r} = B_2qv$$

$$m = \frac{B_2qr}{v}$$

$$= \frac{B_1B_2qr}{E}$$

$$= \frac{2.0\times10^{-5}\times1.2\times2\times1.60\times10^{-19}\times0.30}{6.0\times10^{2}}$$

$$= 3.8 \times 10^{-27} \text{ kg}$$

23. **Ans: C**

Magnitude of emf induced = rate of change of magnetic flux linkage

$$|E| = \frac{\Delta\Phi}{\Delta t}$$

$$= \frac{NA\Delta B}{\Delta t}$$

$$= \frac{N\pi\left(\frac{d}{2}\right)^2\Delta B}{\Delta t}$$

$$= \frac{(120)\pi\left(\frac{0.30}{2}\right)^2(0.080-0.020)}{4.0}$$

$$= 0.127 \text{ V}$$

$$\approx 130 \text{ mV}$$

(Even when the ends of the coil are not connected to form a closed circuit, there is still an emf induced in it due to the decreasing magnetic flux linkage.)

24. **Ans: B**

Using the right-hand grip rule, the current in the vertical wire produces a magnetic field which is directed into the plane of the paper at the location of the loop. Hence, this produces a magnetic flux linkage Φ with the loop. As the loop moves to the right, Φ decreases. By Faraday's law, an emf is induced in the loop and an induced current flows in the loop because it is a closed circuit. By Lenz's law, the current flows in such a direction so as to oppose the decrease in Φ. Using the right-hand grip rule, the current flows clockwise around the loop, so as to produce a magnetic field which is directed into the plane of the paper (within the loop).

Also, by Lenz's law, the induced current will produce a magnetic force which opposes the motion of the loop. So the net magnetic force on the loop will be to the left.

25. Ans: D

Mean power $P_{ave} = ½ P_{max}$

$$= \frac{1}{2}\frac{V^2}{R}$$

26. Ans: D

$$E_2 - E_1 = \frac{hc}{\lambda_2} = \frac{6.63\times10^{-34}\times3.00\times10^{8}}{1.78\times10^{-7}}$$

$$= 1.12\times10^{-18} \text{ J}$$

$$E_3 - E_2 = \frac{hc}{\lambda_1} = \frac{6.63\times10^{-34}\times3.00\times10^{8}}{6.22\times10^{-7}}$$

$$= 0.32\times10^{-18} \text{ J}$$

Hence $E_3 - E_1 = (1.12 + 0.32)\times10^{-18}$

$$= 1.44\times10^{-18} \text{ J}$$

$$= 9.00 \text{ eV}$$

Hence the minimum p.d to excite electrons must be 9.00 V.

27. Ans: D

Heisenberg's uncertainty principle, $\Delta p\Delta x \geq h$

Minimum uncertainty in the momentum, $\Delta p = m\Delta v = \dfrac{h}{\Delta x}$

Minimum uncertainty in the speed, $\Delta v = \dfrac{h}{m\Delta x}$

k.e. = $½ mv^2$

Minimum $\dfrac{\Delta \text{k.e.}}{\text{k.e.}}$ = 2 x minimum $\dfrac{\Delta v}{v}$

$$= \frac{2h}{mv\Delta x}$$

$$= \frac{2h}{p\Delta x}$$

$$= \frac{2 \times 6.63 \times 10^{-34}}{2 \times 10^{-22} \times 1 \times 10^{-10}}$$

= 0.07 or 7%

28. Ans: A

$$\lambda_{min} = \frac{hc}{eV}$$

$$\Rightarrow \lg \lambda_{min} = \lg\left(\frac{hc}{e}\right) - \lg V$$

Hence plotting lgλ_{min} vs lgV would be a straight line graph with negative gradient.

29. Ans C

With a release of energy, products X and Y are more stable than reactants P and Q. Hence total binding energy for X and Y is larger.

30. Ans: D

Initial **actual** count rate C_o = 39.0 – 5.0 = 34.0 s^{-1}

After 20 mins = 2 half-lives, the count rate becomes 34.0 x $(1/2)^2$ = 8.5 s^{-1}

Since radioactive decay is random and the sample is a point source, then the count rate will be inversely proportional to the square of the distance from source to detector, ie.

$$C \propto \frac{1}{r^2}$$

$$\frac{C'}{C} = \frac{\frac{1}{20^2}}{\frac{1}{40^2}} = 4$$

That means the count rate at 20 cm from the source would measure 4 times the count rate at 40 cm from source. Thus the count rate at the 20 cm position would read 8.5 x 4 = 34.0 s^{-1}

The **measured** count rate at the 20 cm position would be 34.0 + 5.0 = 39.0 s^{-1}