2023 VCAA NHT Physics Solutions

Section A Multiple choice

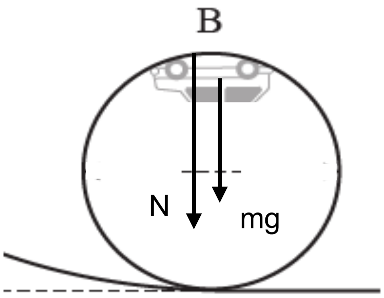
2024 Sample Question 1, 1 mark

The stem of the question states 'He holds it stationary off the ground', therefore the net force is zero.

∴ A (ANS)

2024 Sample Question 2, 1 mark

(similar to 2019 Question 8b, 53%)



Use $\frac{mv^2}{r} = N + mg$

$\therefore \frac{0.250 \times 1.40^2}{0.20} = N + 0.250 \times 9.80$

$\therefore N = 2.45 - 2.45$

$\therefore N = 0$

∴ A (ANS)

2024 Sample Question 3, 1 mark

Since this question can be solved using a ratio concept, it is appropriate to leave the units as km h^{-1}.

Use $v^2 - u^2 = 2as$.

As the final speed, $v = 0$, in both cases, the stopping distance s is directly proportional to v^2.

$\therefore s_{new} = \frac{30^2}{50^2} d$

$\therefore s_{new} = 0.36d$

∴ B (ANS)

2024 Sample Question 4, 1 mark

(previously 2019 Question 20, 36%)

The purpose of the crumple zone (crumpling action) is to extend the time of the impact. It also takes energy to deform the vehicle (in the crumpling action), so it absorbs some of the initial KE.

∴ B (ANS)

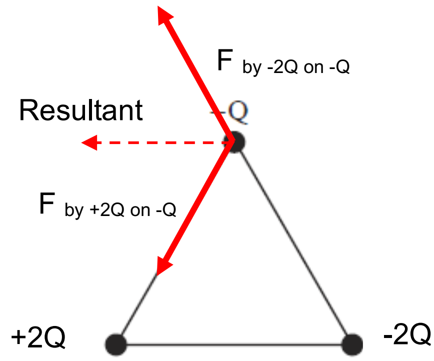
2024 Sample Question 5, 1 mark

The electric field is defined as the direction of the electric force on a small positive charge. Therefore the left hand charge is positive, as the field is 'away' and the right hand charge is negative.

∴ C (ANS)

2024 Sample Question 6, 1 mark

(similar to 2021 NHT Question 2)



The vector sum of the two forces by the two charges will be horizontal to the left.

∴ A (ANS)

2024 Sample Question 7, 1 mark

Consider the left hand end of the coil, the current is up the front of the coil. Using the right hand grip rule will give a magnetic field to the left. Therefore the field at X is also to the left. Using the right hand force rule gives the force on the current carrying wire to be out of the page.

∴ D (ANS)

2024 Sample Question 8, 1 mark

There is only one force acting on the satellite, the gravitational attraction towards the centre of Earth.

∴ D (ANS)

2024 Sample Question 9, 1 mark

Use $P = VI$

$\therefore 15 = V \times 1.5$

$\therefore V = 10\ V_{RMS}$

$\therefore V_{P\text{-}P} = V_{RMS} \times 2\sqrt{2}$

$\therefore V_{P\text{-}P} = 28\ V$

∴ D (ANS)

2024 Sample Question 10, 1 mark

The torque is given by $\tau = F \times r$

$\therefore \tau = nBiL \times r$

Therefore to increase the torque, either *n, B*, *I*, *L* or *r* needs to be increased.
If the resistance of the wire is decreased, and the voltage of the battery is unchanged then the current will increase.

$\therefore$ D (ANS)

2024 Sample Question 11, 1 mark

Even though it is not that clear on the diagram, position 1 is outside the field between the two magnets.
There will be an induced EMF (and hence an induced current) when the flux through the loop changes. This will be when the loop enters the field and exits the field, as shown by the flux vs position graph.
The current will be proportional to the gradient of the flux vs position graph, because the loop is moved at a constant speed, and so the flux vs time graph will have the same shape.
As the flux increases the current will flow in one direction and as the flux decreases the current will flow in the opposite direction.

$\therefore$ A (ANS)

2024 Sample Question 12, 1 mark

When the frequency is doubled, two changes occur, the period will halve and the magnitude of the output will double.
When the slip rings are replaced with the split-ring commutator, the output will change from AC to DC.
Combing these gives

$\therefore$ D (ANS)

2024 Sample Question 13, 1 mark

The role of the inverter is to convert the DC output from the photovoltaic cell into an AC signal.

$\therefore$ C (ANS)

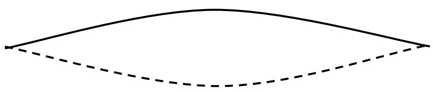
2024 Sample Question 14, 1 mark

An accelerating charge creates a changing current. Every current is surrounded by a magnetic field, so every changing current is surrounding by a changing magnetic field. The associated electric and magnetic fields regenerate each other to make up an **electromagnetic wave** emanating from the accelerating charge**.**

$\therefore$ A (ANS)

2024 Sample Question 15, 1 mark

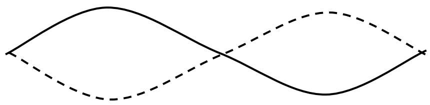
The fundamental occurs when there is a node at both and an antinode in the middle, see below.



$\therefore \frac{1}{2}\lambda = 6.0$ m

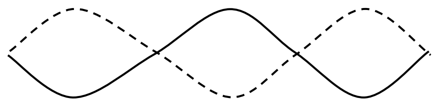
$\therefore \lambda_{\text{fundamental}} = 12.0$ m

The next time there are two antinodes between the two nodes at either end.



$\therefore \lambda = 6.0.0$ m

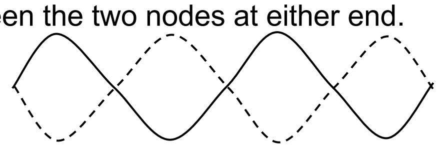
The next time there are three antinodes between the two nodes at either end.



$\therefore \frac{3}{2}\lambda = 6.0.0$ m

$\therefore \lambda = 4.0$ m

The next time there are four antinodes between the two nodes at either end.



$\therefore 2\lambda = 6.0.0$ m

$\therefore \lambda = 3.0$ m

λ being equal to 5.0 m does not resonate.

$\therefore$ B (ANS)

2024 Sample Question 16, 1 mark

The lowest energy photon that can be emitted as the energy associated with the transmission when moving the smallest gap between two possible energy levels.

$n_3 \rightarrow n_2 = 5.2 - 3.4$
$= 1.8$ eV

$n_2 \rightarrow n_1 = 3.0 - 0$
$= 3.4$ eV

$n_3 \longrightarrow n_1 = 5.2 - 0$
$= 5.2$ eV
∴ **B (ANS)**

2024 Sample Question 17, 1 mark

(similar to 2013 Question 10, 50%)

In the satellite's frame of reference the time interval 1 s, is the proper time, t_0 (as one clock is used to measure the time interval) The student will measure the time interval of something in a relatively moving frame, so they're measuring the dilated time, t.
Use , $t = t_0 \times \gamma$
∴ $t = 1 \times (1 + [5 \times 10^{-11}])$
∴ **C (ANS)**

2024 Sample Question 18, 1 mark

Use $E_K = (\gamma - 1)mc^2$
∴ $E_K = (3.2 - 1) \times 9.1 \times 10^{-31} \times (3.0 \times 10^8)^2$
∴ $E_K = 1.8 \times 10^{-13}$ J
∴ **B (ANS)**

2024 Sample Question 19, 1 mark

The variable that is being measured is the period. If the uncertainty in the one measurement is spread over the five oscillations, then the uncertainty in the measured period is reduced.
∴ **C (ANS)**

2024 Sample Question 20, 1 mark

(2021 Question 1, 87%)

The idea of precision is that all the data points a close to each other, (therefore A and D are both precise) and the idea of accurate is that the data is close to the accepted value, (in this case the bulls eye). Therefore D is precise but inaccurate
∴ **D (ANS)**

Section B

2024 Sample Question 1a, 1 mark

Use F = ma
∴ $35 = (25 + 45) \times a$
∴ $a = \frac{35}{70}$
∴ **a = 0.50 m s^{-2} (ANS)**

2024 Sample Question 1b, 1 mark

The only force (in the direction of motion) acting on Shanna's brother and trailer, is the force that results in their acceleration.
∴ $F = 25 \times 0.5$
∴ $F = 12.5$ N.
This force is equal and opposite to the force that is exerted on Shanna by her brother and the trailer.
∴ **12.5 N (ANS)**

2024 Sample Question 1c, 1 mark

The only force (in the direction of motion) acting on Shanna's brother and trailer, is the force that results in their acceleration, which is exerted by Shanna.
∴ $F = 25 \times 0.5$
∴ ***F* = 12.5 N. (ANS)**

2024 Sample Question 1d, 1 mark

If they travel at a constant speed, then the net force acting is zero. Assuming that Shanna's driving force remains constant, then the retarding frictional force opposing the motion cannot be ignored. (This retarding frictional force could be the friction between the tyres and the path, air resistance or friction preventing the wheels from rolling efficiently.)

2024 Sample Question 2a, 2 marks

(similar to 2021 MC Question 9)
This is similar to the 2021 question, and unfortunately Lucinda, still seems to wearing shoes, which may not be wise.

Consider **vertical motion** only.

Use $h = ut + \frac{1}{2}gt^2$ to find the time it will take Lucinda to reach the water.
∴ $8 = 0 + \frac{1}{2}gt^2$
∴ $t^2 = 1.6327$
∴ $t = 1.278$ s

Consider **horizontal motion** only.
Use $d = vt$
∴ $d = 6.0 \times 1.278$
∴ $d = 7.6665$
∴ ***d* = 7.7 m (ANS)**

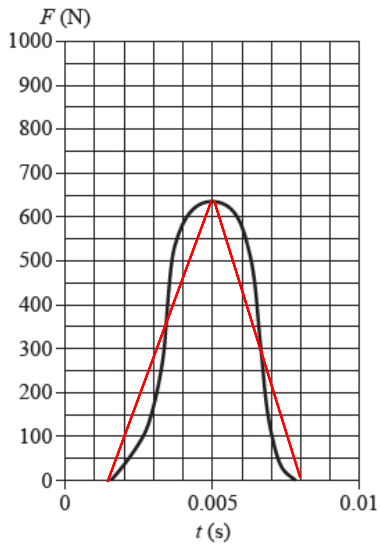
2024 Sample Question 2b, 2 marks

If instead of running straight off the end of the diving board, Lucinda jumped upwards just before launching, she would have a parabolic path. This would take longer for her to land in the water because initially she was travelling away from the water. She would then need to fall back to the water from a greater height.

Lucinda may also want to increase the resistive forces, by arranging her body in a more horizontal orientation, than vertical when in flight.

2024 Sample Question 3a, 2 marks

The impulse acting is given by the area under the graph.



The simplest way to calculate the area under the graph is to draw two lines of best fit. These look close enough as the areas 'above' and 'below' both lines look similar.

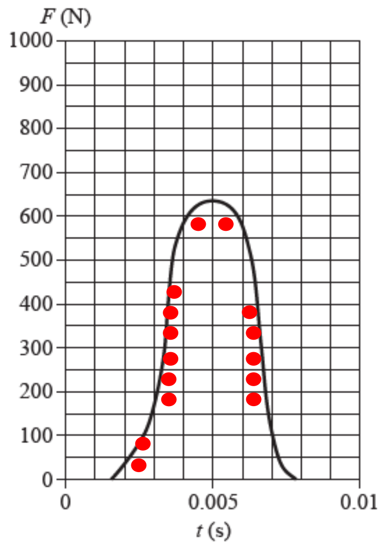
Use A = $\frac{1}{2}bh$

$\therefore$ A = $\frac{1}{2}$ × (0.008 – 0.0015) × 640

$\therefore$ A = 2.08

$\therefore$ **2.1 N s (ANS)**

The other method is to count squares



I count 28 full squares plus 13 part squares, which I count as '1'.

$\therefore$ I count 43 squares.

Each square as an area of

50 × 0.001 = 0.05

$\therefore$ 43 × 0.05 = 2.15 N s

$\therefore$ **2.2 N s (ANS)**

Both answers should be within the acceptable range.

2024 Sample Question 3b i, 2 marks

This answer is dependent on your answer to question 3a. If you are unable to answer question 3a, do not leave it blank, write in a number. (Don't use 1 as your number because it is too simplistic). Use your answer to 3a to solve 3b i.

Use $I = m\Delta v$

$\therefore$ 2.08 = 0.060 × v

$\therefore$ v = 34.7 m s^{-1}

The answer needs to be in km h^{-1} therefore multiply by 3.6

$\therefore$ v = 124.8 km h^{-1}

$\therefore$ ***v* = 120 km h^{-1} (ANS) (2 sig figs)**

2024 Sample Question 3b ii, 2 marks

As the impulse given to the practice ball will be the same, from $I = m\Delta v$ and increase in m will result in a decrease in Δv, so the speed the practice ball leaves the racquet will be less.

2024 Sample Question 4a, 2 marks

The change in GPE = $mg\Delta h$

$\therefore \Delta GPE = 4.0 \times 9.8 \times 0.050$

$\therefore$ **ΔGPE = 1.96 J (ANS)**

2024 Sample Question 4b, 2 marks

At the rest position when the mass has been lowered, the net force is zero.

$\therefore mg = k\Delta x$

The mass suspended is 1.0 + 4.0 = 5.0 kg.
The bouncer's spring has extended by 0.05 mm due to the addition of the 4.0 kg mass, therefore the 1.0 kg of the actual bouncer will have also extended the spring by 0.0125 m

$\therefore 5.0 \times 9.8 = k \times (0.050 + 0.0125)$

$\therefore k = 784 \text{ N m}^{-1}$

Use E = $\frac{1}{2}kx^2$

$\therefore E = \frac{1}{2} \times 784 \times 0.0625^2$

$\therefore$ **E = 1.53 J (ANS)**

2024 Sample Question 4c, 2 marks

No.
When the bouncer was hung by itself from the door frame, the KE of the system was zero. The final KE was also zero.
Therefore for energy to be conserved, gain in spring energy must equal the loss in GPE. The bouncer also loses GPE when it is lowered the 0.050 m when the mass is added.

$\therefore \Delta GPE_{total} = 5.0 \times 9.8 \times 0.050$

$\therefore \Delta GPE_{total} = 2.45 \text{ J}$

The energy stored in the spring is 1.53 J, therefore is not conserved.
The person lowering the mass by hand is exerting a force on the mass as it moves. This means that the mass-spring system is doing work on the hand.

2024 Sample Question 5a i, 2 marks

Use $F = \frac{GMm}{r^2}$ and $F = \frac{mv^2}{r}$

with $v = \frac{2\pi r}{T}$

Which gives $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$

$\therefore T^2 = \frac{4\pi^2 r^3}{GM}$

$\therefore T^2 = \frac{4\pi^2(6.37\times10^6 + 550\times10^3)^3}{6.67\times10^{-11}\times5.98\times10^{24}}$

$\therefore T^2 = 32{,}798{,}274.94$

$\therefore T = 5{,}727$

$\therefore$ **T = 5.73 ×10³ s (ANS)**

2024 Sample Question 5a ii, 2 marks

1 day = 60 × 60 × 24 s

$\therefore$ 1 day = 86,400 s

Orbits per day = $\frac{86{,}400}{5{,}727}$

$\therefore$ 15.08 orbits per day

$\therefore$ **15 complete orbits per day (ANS)**

2024 Sample Question 5b, 2 marks

Use $v = \frac{2\pi r}{T}$

$\therefore v = \frac{2\pi\times6.92\times10^6}{5727}$

$\therefore v = 7{,}592$

$\therefore$ **v = 7.59 × 10³ m s⁻¹ (ANS)**

2024 Sample Question 5c i, 2 marks

Assume that the steering process doesn't noticeably change the energy of the old satellites.
The total energy of the satellite will remain constant, as it descends towards Earth, its GPE will decrease, therefore its KE must increase.
Therefore it will be faster.

2024 Sample Question 5c ii, 1 mark

As the old satellites enter the Earth's atmosphere, the frictional drag produces sufficient heat to burn the satellite.

2024 Sample Question 6a, 1 mark

This is one of those questions where you are given a huge hint in the answer box.
The answer has to have the units of V m^{-1}, which implies that you need to divide a voltage by a distance.

$\therefore$ Use $E = \frac{\Delta V}{d}$

$\therefore E = \frac{10\times10^3}{0.20}$

$\therefore$ **E = 5.0 × 10⁴ V m⁻¹ (ANS)**

2024 Sample Question 6b, 1 mark

The work done, qV, is the gain in KE, which is the energy of the proton. Since the answer needs to be in eV, you can either find the energy in Joule using qV and then divide this answer by 1.6×10^{-19} to convert from J to eV. The other option is to just treat the charge q as 1.

$\therefore$ WD = qV

$\therefore$ WD = $1 \times 10 \times 10^3$

$\therefore$ **E = 1.0×10^4 eV (ANS)**

2024 Sample Question 6c, 2 marks

To calculate the speed from the energy, you need to energy to be in Joule.

$\therefore E = 1.6 \times 10^{-15}$ J

$\therefore \frac{1}{2}mv^2 = 1.6 \times 10^{-15}$

$\therefore v^2 = \dfrac{2 \times 1.6 \times 10^{-15}}{1.7 \times 10^{-27}}$

$\therefore v^2 = 1.88 \times 10^{12}$

$\therefore$ **v = 1.4×10^6 m s^{-1} (ANS)**

Please note that the data given in the table for this question is incorrect. The mass of a proton is 1.7×10^{-27} kg

2024 Sample Question 6d, 2 marks

Use $Bqv = \dfrac{mv^2}{r}$

Which simplifies to $Bqr = mv$

$\therefore r = \dfrac{mv}{Bq}$

$\therefore r = \dfrac{1.7 \times 10^{-27} \times 1.0 \times 10^6}{2.0 \times 10^{-2} \times 1.6 \times 10^{-19}}$

$\therefore r = 0.53125$

$\therefore$ ***r* = 0.53 m (ANS)**

2024 Sample Question 6e, 1 mark

To hit the target in the new position, r needs to be smaller.

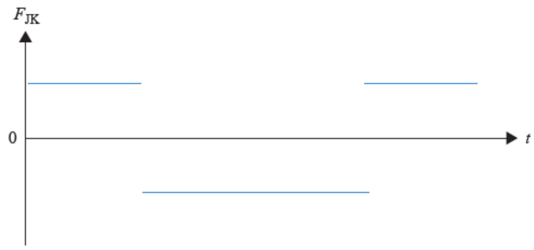
The requires either a smaller mass, or velocity, or a larger magnetic field or charge on the proton.

The charge and mass of the proton are fixed, so either reduce the velocity or increase the magnetic field strength. The simplest is to reduce the velocity by decreasing the accelerating voltage.

2024 Sample Question 7a, 2 marks

The purpose of the split ring commutator is to reverse the direction of the current in the wire every half cycle, so that the force on the current carrying wire reverses every half cycle. The reversal happens when the coil is perpendicular to the field. The reversal of the direction of the force will maintain a constant torque on the loop.

2024 Sample Question 7b, 3 marks



The current in the loop is from M to J, (anticlockwise). The force on the current carrying wire is given by $F = nBiL$. Using the right hand force rule, the force on the current carrying section JK is up, which is considered positive. The force is zero, when the loop has rotated 90^0 and then the force is of the same magnitude but in the opposite direction for the next half cycle, returning to original size and direction for the remaining 90^0.

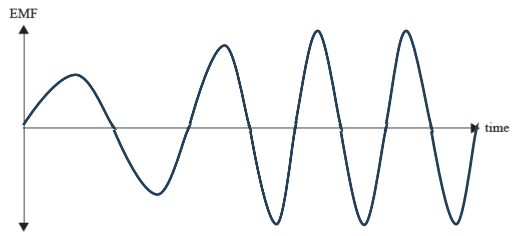
2024 Sample Question 8a, 1 mark

Use $\phi = BA$

$\therefore 2.0 \times 10^{-3} = 0.8 \times A$

$\therefore$ **A = 2.5×10^{-3} m^2 (ANS)**

2024 Sample Question 8b, 2 marks



The initial flux is a maximum, so the EMF graph starts from zero. As the frequency increases the period must shorten, and the magnitude of the induced EMF must increase. So the first 4 ‘half loops’ must have a decreasing horizontal 'length' and increasing vertical 'height' to represent these changes. After the second full cycle the shape must remain constant. For clarity there are 4 cycles shown.

Since values are not required, the orientation of the graph is not critical.

2024 Sample Question 8c, 3 marks

For the first quarter turn, use

$$EMF = -n\,\frac{d\Phi}{dt}$$

$$\therefore 40 = 500 \times \frac{(2.0\times10^{-3}-0)}{t}$$

$$\therefore t_{\text{¼ turn}} = 500 \times \frac{2.0\times10^{-3}}{40}$$

$$\therefore t_{\text{¼ turn}} = 0.025 \text{ s}$$

$$\therefore t_{\text{full turn}} = 0.1 \text{ s}$$

Use $f = \frac{1}{T}$

$$\therefore f = \frac{1}{0.1}$$

$\therefore f = 10$ Hz (ANS)

2024 Sample Question 8d, 2 marks

The purpose of the slip rings is to maintain a constant point of contact with the rotating loop so that the output to the CRO alternates. This will produce an AC signal at the CRO.

2024 Sample Question 9a, 1 mark

The power supplied by the system is 12 kW.
With 24 cells, each cell will provide

$$\frac{12000}{24} = 500 \text{ W}$$

2024 Sample Question 9b, 1 mark

Use $P = VI$

$\therefore 500 = V \times 20$

$\therefore V = 25$ Volt (ANS)

2024 Sample Question 9c, 2 marks

When connected in series, the voltages across individual cells will sum to give the total voltage produced, and the current through each cell will be the same.

Therefore the voltage across the series connection is

24 × 25 = 600 V

The current will remain at 20 A (from part b).

∴ 600 V (ANS)

∴ 20 A (ANS)

2024 Sample Question 9d, 2 marks

When connected in parallel, the currents from individual cells will sum to give the total current produced, and the voltage across one cell will be the voltage across the system. Therefore the current in the series connection is 20 × 24 = 480 A

∴ 25 V (ANS)

∴ 480 A (ANS)

2024 Sample Question 9e, 3 marks

Joe is correct.
There will be some power lost in the transmission lines from the paddock to the dairy, therefore to minimise energy losses in transmission the lowest current is preferred. With the transmission resistance of 1Ω, and a current of 20 A, the input voltage to the diary will be 580 V. A step down transformer will be needed to operate the dairy machinery.

2024 Sample Question 9f, 1 mark

The role of the inverter is to convert the DC produced by the solar photovoltaic cells into AC which is suitable to be used in most dairy machinery.

2024 Sample Question 10a, 2 marks

The bright bands are the results of constructive interference, and the dark bands are the results of destructive interference.
Constructive interference occurs when the path difference from the two slits is a multiple of λ, i.e. 0, λ, 2λ, 3λ, etc.
Destructive interference occurs when the path difference is a multiple of $\frac{1}{2}\lambda$.

Therefore band X must be the position where the path difference from the slits is $\frac{5}{2}\lambda$.

2024 Sample Question 10b, 2 marks

Higher frequency means a shorter wavelength. From $\Delta x = \frac{\lambda L}{d}$, to keep Δx constant (without changing L)as λ decreases, so must d.
Therefore slit separation needs to be reduced.

2024 Sample Question 10c, 2 marks

Young's double slit experiment with light demonstrated interference, which was a wave effect. When the light passed through the two narrow slits it diffracted. The diffracted light from both slits interfered with each other and produced a pattern of light and dark lines. The interference was both constructive and destructive from the superposition of waves. The bright bands were the result of constructive interference when the path difference from the two sources was a multiple of nλ. The dark bands were the result of destructive interference when the path difference from the two sources was given by $(n + \frac{1}{2})\lambda$.

This interference pattern can only be explained when light is modelled as a wave, as interference is a wave property.

2024 Sample Question 11a, 3 marks

Using KE = $hf - \phi$, where the KE is measured by the stopping voltage, and $hf = \frac{hc}{\lambda}$ is the energy of the incident light.
It is simplest to work in eV.

$$0.47 = \frac{4.14 \times 10^{-15} \times 3 \times 10^{8}}{450 \times 10^{-9}} - \phi$$

$\therefore 0.47 = 2.76 - \phi$

$\therefore$ **ϕ = 2.29 eV (ANS)**

2024 Sample Question 11b, 3 marks

Using light with a shorter wavelength, i.e a higher frequency, will mean that the incident photons have more energy. Therefore the ejected photoelectrons will have more energy and it will take a larger stopping voltage to prevent them from reaching the collector. Since the source delivers the same light output power as the original, if the photons have more energy, there must now be fewer photons coming from the light source. The photocurrent depends on the number of photons (i.e. the intensity of the incident light). Therefore Bruce is correct about the stopping voltage, and the maximum photocurrent.

Denise is correct about the effect on the stopping voltage, and somewhat (incorrectly) vague (about the photocurrent depending on the intensity of the incident light).

I think Denise is incorrect when she states that changing the wavelength will **only** affect the stopping voltage. If the wavelength is such that the frequency is below the cut off frequency, then photoelectrons will not be emitted.

2024 Sample Question 11c, 3 marks

The tension needed to be applied by the string is greater at B than A. At the top, the Tension and the weight are both acting in the same direction to provide the constant net force. At B the tension needs to oppose the weight force and still provide a net force radially inwards. Therefore the tension at the bottom is greater than the tension required at the top. Therefore the string will break at B.

2024 Sample Question 12a, 3 marks

The diffraction is given by the ratio of $\frac{\lambda}{w}$, where λ is the wavelength and w is the gaps in the sample.

To get the same spacing of the bands the wavelength of the electrons needs to be the same as that of the X-rays.

Therefore the similarities of the patterns demonstrates that electrons exhibit wave like properties and have a wavelength.

2024 Sample Question 12b, 2 marks

The electrons energy of 3.0×10^{3} eV needs to be converted in joules
$\therefore 3000 \times 1.6 \times 10^{-19} = 4.8 \times 10^{-16}$ J
The simplest way to find λ is to use
$p = \sqrt{2mE}$ and then $p = \frac{h}{\lambda}$

$$\therefore \sqrt{2mE} = \frac{h}{\lambda}$$

$$\therefore \lambda = \frac{h}{\sqrt{2mE}}$$

$$\therefore \lambda = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 4.8 \times 10^{-16}}}$$

$\therefore$ **λ = 2.2 × 10^{-11} m (ANS)**

2024 Sample Question 13, 4 marks

Michelson and Morley thought that light was traveling on the ether, and expected to be able to measure the speed of light with respect to the ether. They thought that there would be an ether wind, so the measured speed of light would be different in different directions.

They sent light beams at right angles to each other and observed the resulting interference patterns at different orientations of the apparatus to see if they could detect changes in the difference in the speed of light between the two directions due to the possible motion of the Earth through the ether.

The speed of light was the same in all directions, so there was no evidence for the ether.

This null observation infers that:

light travels at the same speed in the two directions.

the speed of light doesn't depend on the motion of a reference frame relative to the ether.

there is no absolute frame of reference.

These findings are consistent with Einsteins postulate that the speed of light was constant for all observers regardless of the motion of the light source or the observer.

2024 Sample Question 14a, 2 marks

I find this question a bit unusual. Up until this year the diagrams for an emission spectrum have ALWAYS been white (bright) bands on a black (dark) background. The absorption spectrum have always been black (dark) bands on a white (light) background. In this sample paper this has been reversed.

An absorption line will appear in a spectrum if an absorbing material (in this case hydrogen gas) is placed between a source and the collector.

According to quantum mechanics, an atom, element or molecule can absorb photons with energies equal to the difference between two energy states.

Photons with specific energies will be absorbed by hydrogen if this energy is equal to the difference between the energy levels.

This absorbed light is re-emitted from the hydrogen atom, but in a random direction.

Thus the light reaching the observer (collector) will have a reduced amount of those absorbed frequencies and (usually dark) lines appear in the spectrum of light from the source.

2024 Sample Question 14b, 2 marks

The emission spectrum is produced when an electric current is passed through a glass tube containing Hydrogen gas. This sends the electrons in the hydrogen atoms to higher energy levels. The electrons orbit the nucleus at discrete energy levels. When an electron transitions between shells (in this case drops down), energy is given off in the release of a photon. The photons can only have discrete energies that correspond to the difference between two levels.

Therefore only discrete spectral lines are observed.

2024 Sample Question 15a, 1 mark

The uncertainty in the measurement of the mass of each washer. The measured mass of each washer is in the range of 29.9 – 30.1 g.

2024 Sample Question 15b, 1 mark

(same as 2021 Question 20b, 17%)

The tension is provided by the gravitational force by the earth on the washers.

2024 Sample Question 15c, 2 marks

The period is the time taken for one revolution.

$\therefore$ 12.8 ÷ 20 **= 0.64 (ANS)**

1.75^2 = **3.06 (ANS)**

2024 Sample Question 15d i, 2 marks

(same as 2021 Question 20c, 34%)

The gravitational force *Mg*, is going to provide the tension in the string, that will provide the net force on the stopper.

The force on the stopper = $\dfrac{mv^2}{R}$

where $v = \dfrac{2\pi R}{T}$, $\therefore v^2 = \dfrac{4\pi^2 R^2}{T^2}$

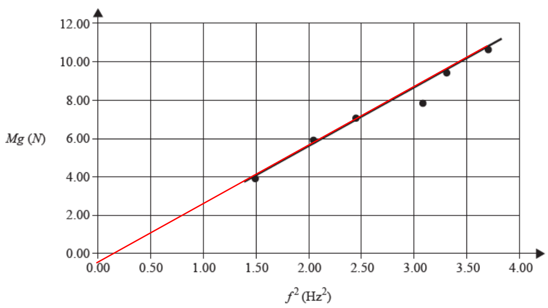
and $f = \dfrac{1}{T}$, $\therefore \dfrac{1}{T^2} = f^2$

$$\therefore Mg = \frac{mv^2}{R}$$

$$\therefore Mg = \frac{m4\pi^2 R}{T^2}$$

$\therefore Mg = 4\pi^2 Rmf^2$ as required.

2024 Sample Question 15d ii, 2 marks



My extrapolation crosses the x-axis at f^2 = 0.1. This suggests that when the mass, M, was equal to zero, the rubber stopper was still moving. This could be explained by the friction between the string and the glass tube. This may be due to the dip of the washers below the horizontal as mentioned in the question stem.

Since the graph did not uncertainties plotted, it would be reasonable to assume that the line of best fit should not be extrapolated to the origin

2024 Sample Question 15d iii, 2 marks

To calculate the gradient of the line, you MUST use two points on the line (not two dots).

Use (3.50, 10.2) and (1.50, 4.1)

Use gradient = $\dfrac{rise}{run}$

$\therefore$ gradient = $\dfrac{10.2 - 4.1}{3.50 - 1.50}$

$\therefore$ **gradient = 3.05 N Hz^{-2} (ANS)**

2024 Sample Question 15d iv, 2 marks

When $Mg = 4\pi^2 Rmf^2$ is plotted as a graph of *Mg* vs f^2 the gradient of the line is equal to $4\pi^2 Rm$.

$\therefore 3.05 = 4\pi^2 Rm$ where R = 0.5 m

$$\therefore m = \frac{3.05}{4\pi^2 \times 0.75}$$

$\therefore m$ = 0.103

$\therefore$ ***m* = 0.10 kg (ANS)**

2024 Sample Question 15d v, 2 marks

If the frequency was correctly measured, then the total mass of the washers should have been 0.90 kg.

With each washer having a mass of 30 gm, it would require 30 washers to make up the 0.90 kg. The 0.80 kg would have required 27 washers. It would seem reasonable to miscount that many washers.

If the mass was correctly measured, then the time for 20 rotations should have been measured as 12.2 s. Since the rotations were measured three times and then averaged, it is less likely that this would be the mistake.

Therefore Ishva is more likely to be correct