2025 VCAA NHT Physics Solutions

Section A Multiple choice

2025 NHT Question 1, 1 mark

The only force that the slope can exert on the skis is a Normal force perpendicular to the slope.

∴ **B (ANS)**

2025 NHT Question 2, 1 mark

The first thing required is to convert 220 km h^{-1} to m s^{-1} by dividing by 3.6.

$\therefore \frac{220}{3.6} = 61.1 \text{ m s}^{-1}$

Now use $F = \frac{mv^2}{R}$ to find F

$\therefore F = \frac{800 \times 61.1^2}{120}$

$\therefore F = 24{,}897$ N

∴ **C (ANS)**

2025 NHT Question 3, 1 mark

At the instant the ball is stationary, it will remain stationary unless a force is acting on it.

As the ball rebounds upwards, then the net force acting on it must be vertically up.

Therefore the normal force from the floor must be greater than the gravitational force acting on the ball

∴ **B (ANS)**

2025 NHT Question 4, 1 mark

The time of flight needs to be determined first.

Consider the vertical motion, with initial speed = 0.

Use $s = ut + \frac{1}{2}gt^2$

$\therefore 36 = 0 + \frac{1}{2} \times 9.81 \times t^2$

$\therefore t^2 = 7.34$

$\therefore t = 2.71$ s

Consider the horizontal direction.

Use $s = v \times t$

$\therefore s = 10 \times 2.71$

$\therefore s = 27.1$ m

∴ **A (ANS)**

2025 NHT Question 5, 1 mark

The energy stored is given by the area under the force - extension graph.

Use EPE = $\frac{1}{2}F\Delta x$

Use $\Delta x = 0.25$ m

$\therefore$ EPE = $\frac{1}{2} \times 80 \times 0.25$

$\therefore$ EPE = 10 J

∴ **A (ANS)**

2025 NHT Question 6, 1 mark

In Diagram 1, the potential difference between X and Y is 100 V. In diagram 2, the PD is 50 V.
Therefore the change in the charge's electrical potential energy will be half of that from Diagram 1

∴ **B (ANS)**

2025 NHT Question 7, 1 mark

The torque is the product of the force acting × distance from the point of rotation. The force acting, F = nBiL, and the radius of action is related to 'w'.

$\therefore \tau = nBiL \times \frac{w}{2}$

∴ **D (ANS)**

2025 NHT Question 8, 1 mark

The acceleration due to gravity is given by $g = \frac{GM}{r^2}$, where M is the mass of the planet and r is the radius of the planet.

If the mass of Argus-3 is $1.5M_E$

and $R_A = \frac{1}{2}R_E$,

then $g_A = \frac{G \times 1.5M}{(\frac{1}{2}r)^2}$,

$\therefore g_A = 6\frac{GM}{r^2}$

$\therefore g_A = 6g$

∴ **C (ANS)**

2025 NHT Question 9, 1 mark

The flux will vary sinusoidally and is at a maximum when the field is perpendicular to the coil. The induced voltage is given by the gradient of the flux vs time graph. When the flux is at a maximum, the

gradient of the flux vs time graph is zero. The gradient is at a maximum when the flux is zero, which is when the coil is parallel to the field.

∴ **D (ANS)**

2025 NHT Question 10, 1 mark

The aim is to deliver the maximum percentage of the input energy at the end of the transmission line.

The power loss in the cables is given by $P = I^2R$. Typically as R is fixed, losses are minimised by reducing I. Higher voltages are used because to deliver a set Power, the greater V is, the less I needs to be, from $P = VI$.

∴ **A (ANS)**

2025 NHT Question 11, 1 mark

The ratio of $\frac{primary\ turns}{secondary\ turns}$ is equal to the ratio of input to output.

360 : 12

∴ 30 : 1

∴ **D (ANS)**

2025 NHT Question 12, 1 mark

The current flows in the direction JKLM.
The field is from North to South.
Using the right hand rule, on side LM, the force is upwards

∴ **D (ANS)**

2025 NHT Question 13, 1 mark

The role of the inverter is to convert the DC input into an AC output.

∴ **A (ANS)**

2025 NHT Question 14, 1 mark

The line QP is a line where the path difference is always zero. Therefore a line of constructive interference. As the distance from the speakers increases the intensity of the signal will decrease as $\frac{1}{r^2}$.

Therefore moving from to X will record a gradual increase in sound level.

∴ **C (ANS)**

2025 NHT Question 15, 1 mark

The work done on the electron is given by qV and the KE is equal to $\frac{1}{2}mv^2$.

Equating these gives

$qV = \frac{1}{2}mv^2$.

If the potential difference is increased by a factor of 100, the speed of the electron will increase by a factor of 10.

Therefore the momentum of the electron will increase by a factor of 10.

Using $p = \frac{h}{\lambda}$, gives that λ will decrease by a factor of 10.

∴ **C (ANS)**

2025 NHT Question 16, 1 mark

Using $v = f\lambda$, gives $40.0 = 8.00 \times \lambda$.

∴ $\lambda = 5.00$ m.

The fundamental has a node at both ends with an antinode in between. The distance between the two ends is $\frac{1}{2}\lambda$.

Therefore the distance between the two ends is 2.50 m

∴ **B (ANS)**

2025 NHT Question 17, 1 mark

The energy of the photon is given by

$E = \frac{hc}{\lambda}$

Light of wavelength 600 nm will have less energy than light with a wavelength of 500 nm.

If 500 nm light has just enough energy to release a photoelectron, then 600 nm light will not have enough energy to release a photoelectron

∴ **A (ANS)**

2025 NHT Question 18, 1 mark

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 found speed of light was the same in all directions.

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

∴ **B (ANS)**

2025 NHT Question 19, 1 mark

A set of precise measurements will have values very close to the mean value of the measurements. Precision gives no indication of how close the measurements are to the true value and is therefore a separate consideration to accuracy.

In this case, more precision id shown when the dots are closer together.

A measurement value is considered to be accurate if it is judged to be close to the true value of the quantity being measured.

In this case, accuracy is when the dots are nearer the centre.

We are looking for precise but inaccurate.

∴ **D (ANS)**

2025 NHT Question 20, 1 mark

The force on the electron is given by $F = Bqv$, where B is the magnetic field, q the charge and v the speed. The force will act perpendicularly to the velocity, therefore the electron will move in a circular path.

For circular motion, $F = \frac{mv^2}{r}$.

Equating the two gives

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

$$\therefore mv = Bqr$$

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

This relationship is a straight line, with a gradient, through the origin.

∴ **A (ANS)**

Section B

2025 NHT Question 1a, 2 marks

Using $F = m_{net} \times a$

∴ $64 = (12 + B) \times 4$

∴ $16 = 12 + B$

∴ **B = 4.0 kg (ANS)**

2025 NHT Question 1b, 2 marks

The force that A exerts on B is the force that accelerates B.

Using $F_{net} = ma$

∴ $F_{\text{on B by A}} = 4 \times 4$

∴ $\boldsymbol{F_{\text{on B by A}}}$ **= 16 N (ANS)**

2025 NHT Question 1c, 2 marks

This is the classic example of Newton's third law.

$F_{\text{on A by B}} = - F_{\text{on B by A}}$

We are asked for the magnitude, therefore it must be the **same**. **(ANS)**

2025 NHT Question 2, 2 marks

The airbag is designed to increase the time of the collision. It expands rapidly and is deflating by the time the body comes into contact with it. This deflation of the bag increases the time of collision.

Using the Impulse equation $F\Delta t = m\Delta v$, an increase in Δt for a fixed value of $m\Delta v$ will lead to a decrease in F.

Hard surfaces result in shorter contact times, or softer surfaces result in longer contact times

The larger F is, the greater the risk that parts of the body will undergo forces that will push the body beyond its elastic limit, resulting in more severe injuries.

2025 NHT Question 3a, 1 mark

Assume the initial Kinetic Energy = 0.

Then the change in KE = $mg\Delta h$.

∴ $\Delta KE = 40.0 \times 9.81 \times 2.50$

∴ $\Delta KE = 40.0 \times 9.81 \times 2.50$

∴ $\Delta KE = 981$ J

2025 NHT Question 3b, 2 marks

Use $KE = \frac{1}{2}mv^2$

∴ $981 = \frac{1}{2} \times 40.0 \times v^2$

∴ $v^2 = 49.07$

∴ $\mathbf{v = 7.00\ m\ s^{-1}}$ **(ANS)**

2025 NHT Question 3c, 2 marks

If the speed on hitting the water, was to double, then her KE would have increased by a factor of 4 (due to the effect of v^2). To

do this the height to drop from would need to increase by a factor of 4.

$\therefore H = 4 \times 2.5$

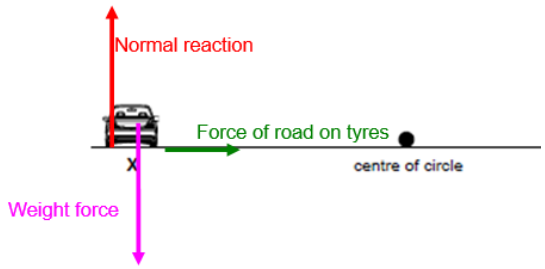
= 10.0 m (ANS)

2025 NHT Question 4a, 1 mark

For circular motion, the net force is always 'radially inwards'.

$\therefore$ C (ANS)

2025 NHT Question 4b, 3 marks



Normal reaction is a contact force, so it must start at the tyre-road interface.

Weight force must act from the centre of mass.

Friction forces act radially inwards from the tyre-road interface.

The normal reaction should be the same length as the weight force.

2025 NHT Question 4c, 2 marks

The force that the 'tyre exerts on the road' is opposite to the force the 'road exerts on the tyre'.

There are two forces that the road exerts on the tyre, the normal and the frictional force. The normal is vertically upwards and the frictional force is radially inwards. These two forces will sum to be 'H'.

The answer is the opposite to 'H' which is "G"

$\therefore$ G (ANS)

2025 NHT Question 5a, 3 marks

As both Vesta and Earth orbit the Sun, the ratio of $\frac{r^3}{t^2}$ will be the same for both. As this is using ratio's it is simpler to leave all times in days.

$$\frac{r_E^3}{t_E^2} = \frac{r_V^3}{t_V^2}$$

$$\therefore \frac{(1.5\times10^{11})^3}{365^2} = \frac{(3.53\times10^{11})^3}{t_V^2}$$

To simplify the arithmetic, 10^{11} will cancel from both sides.

$$\therefore \frac{(1.5)^3}{365^2} = \frac{(3.53)^3}{t_V^2}$$

$$\therefore t_V^2 = \frac{(3.53)^3 \times 365^2}{(1.5)^3}$$

$$\therefore t_V^2 = 1.736 \times 10^6$$

$\therefore t_V = 1.32 \times 10^3$ days (ANS)

2025 NHT Question 5b, 3 marks

The acceleration due to gravity is given by $g = \frac{GM}{r^2}$, where M is the mass of the planet and r is the radius of the planet.

The acceleration required for Dawn is $\frac{v^2}{r}$

$$\therefore \frac{GM}{r^2} = \frac{v^2}{r}$$

$$\therefore \frac{GM}{r} = v^2$$

$$\therefore v^2 = \frac{6.67\times10^{-11}\times2.59\times10^{20}}{(262+140)\times10^3}$$

$$\therefore v^2 = 4.297 \times 10^4$$

$\therefore v = 207$ m s^{-1} (ANS)

2025 NHT Question 5c, 2 marks

As $v^2 = \frac{GM}{r}$ if r becomes smaller, v^2, hence v, will **increase**.

2025 NHT Question 6a, 2 marks

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

$$\therefore E = \frac{5.0\times10^3}{2.0\times10^{-2}}$$

$\therefore E = 2.50 \times 10^5$ V m^{-1} (ANS)

2025 NHT Question 6b i, 2 marks

Using the right hand rule, with the magnetic field into the page and the current to the left (electrons move to the right), the force on the electrons is down

the page. To maintain motion in a straight line the **force** due to the electric field needs to be up the page.

Therefore the electric field is down the page.

∴ **Down the page. (ANS)**

2025 NHT Question 6b ii, 2 marks

To find the speed of the electrons equate the magnetic force to the electric force.

$\therefore Bqv = Eq$

$\therefore Bv = E$

$\therefore 3.6 \times 10^{-3} \times v = 1.5 \times 10^{5}$

$\therefore$ **$v = 4.17 \times 10^{7}$ m s^{-1} (ANS)**

2025 NHT Question 6b iii, 3 marks

The force due to the magnetic field varies with v. Therefore the magnetic force down the page will decrease as the speed decreases.

The force due to the electric field remains constant. Therefore the force down is smaller than the force upwards.

This will result in a net force up, so the path of the electrons will curve upwards.

2025 NHT Question 7a, 3 marks

Both Chen and Darika are incorrect. The gravitational field from the Earth varies as $g = \frac{GM}{r^2}$, so g will have a value greater than 0. Therefore the **gravitational force** acting will be > 0. Chen's statement that 'there is no gravity where there is no air ...' is incorrect.

Darika is correct in saying that the force due to gravity is acting on the astronaut, but incorrect when saying "there is a force created by the movement around Earth".

2025 NHT Question 7b, 2 marks

The ISS is in a stable orbit around the Earth. The spacecraft is accelerating towards the Earth at a rate given by $g = \frac{GM}{r^2}$ as is the astronaut.

As the astronaut and the spacecraft are both accelerating towards Earth at the same rate, the normal force of the spacecraft on the astronaut = 0. Therefore the astronaut 'floats' around the cabin.

2025 NHT Question 8a, 2 marks

Power is given by $P = VI$

$\therefore 500 = 220 \times I$

$\therefore$ **$I = 2.27$ A (ANS)**

2025 NHT Question 8b i, 2 marks

When the appliances are turned on, the effective resistance of the house decreases, (as the appliances are in parallel) therefore the current supplied by the generator increases.

The resistance of the transmission cables results in a voltage drop across the cables when a current flows.

As the cables and the house create a series circuit, the voltage drop across the cables results in a lower voltage being available at the house.

2025 NHT Question 8b ii, 2 marks

If the generator supplied 220 V RMS and only 210 V RMS was available at the house, then the voltage drop across the transmission line was 10 V.

Use $V = iR$,

$\therefore 10 = 2.1 \times R$

$\therefore R = 4.76$

$\therefore$ **$R = 4.8\ \Omega$ (ANS)**

2025 NHT Question 9a, 2 marks

The output of the generator is an AC voltage, with a peak of 5 V. (The regular period is due to very constant rotation.)

$\therefore$ **$V_{Peak} = 5.0$ V (ANS)**

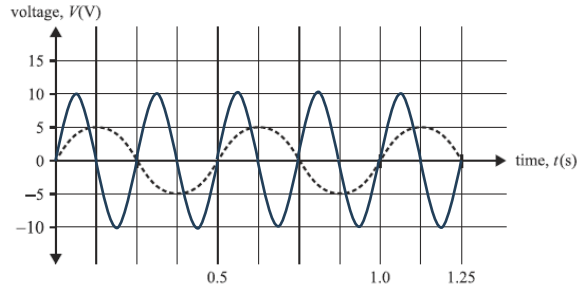
2025 NHT Question 9b, 2 marks

Use $f = \frac{1}{T}$, where T is the time for one cycle.

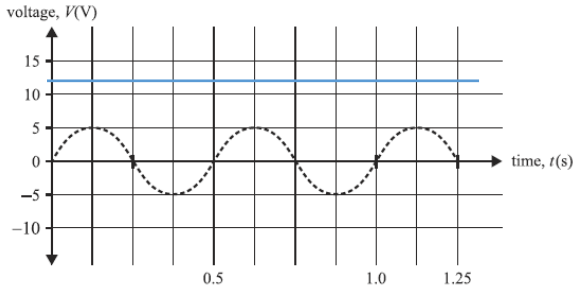
$\therefore f = \frac{1}{0.5}$

$\therefore$ **$f = 2.0$ Hz (ANS)**

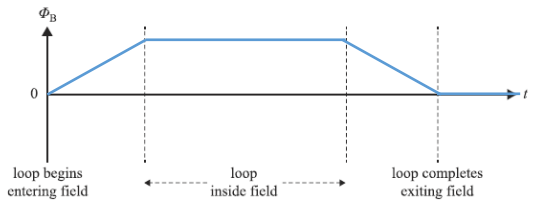
2025 NHT Question 9c, 2 marks



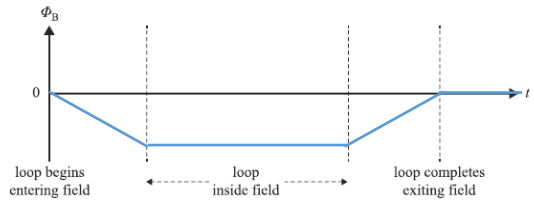
2025 NHT Question 9d, 1 mark



2025 NHT Question 10a, 2 marks

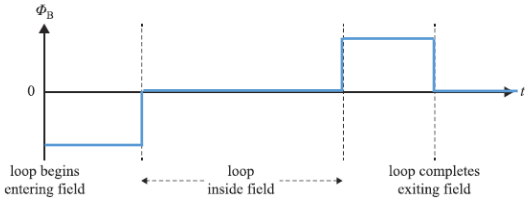


The direction for +ve flux has not been defined in the question, so the second graph is also correct.

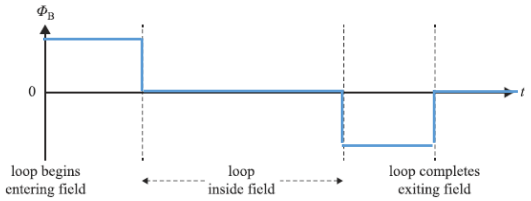


2025 NHT Question 10b, 2 marks

The EMF is the negative gradient of the flux vs time graph.
Therefore either



or



2025 NHT Question 10c, 3 marks

The magnitude of the induced EMF in the loop is given by the rate of change of the flux.

In the 1.5 secs the flux goes from zero to maximum.

$\therefore \Phi = B \times A$
$\therefore \Phi = 1.4 \times 1.0 \times 10^{-2}$
$\therefore \Phi = 1.4 \times 10^{-2}$

The EMF induced is given by

$$\therefore \text{EMF} = n\frac{\Delta\Phi}{\Delta t}$$

$$\therefore \text{EMF} = 1 \times \frac{1.4 \times 10^{-2}}{1.5}$$

$\therefore$ **EMF = 9.3×10^{-3} V (ANS)**

2025 NHT Question 10d, 3 marks

The induced EMF creates a current that has a magnetic field to oppose the change that created it.

As viewed from above, the flux is downwards and it is decreasing as the loop moves out of the magnetic field.

The induced current will flow to create a magnetic field that will oppose this decrease in flux.

So the induced current will flow clockwise, (this way it creates a magnetic field downwards) to oppose the change in flux by supplementing it.

$\therefore$ **Clockwise (ANS)**

2025 NHT Question 11a, 2 marks

Use $\Delta x = \frac{\lambda L}{d}$, where
Δx = 42 cm, L = 1.5 m and d = 10 cm.

$$\therefore 0.42 = \frac{\lambda \times 1.5}{10 \times 10^{-2}}$$

$\therefore \lambda = 0.028$ m
The answer is required in cm,

$\therefore$ **λ = 2.8 cm (ANS)**

2025 NHT Question 11b, 2 marks

The path difference for the two waves coming from S_1 and S_2 is exactly $1\frac{1}{2}\lambda$.

This will give rise to destructive interference which will result in a local minimum at this point.

2025 NHT Question 11c, 2 marks

If the frequency of the microwaves is doubled, the wavelength will halve, from $c = f\lambda$, where c is constant.

The point Y, is such that the distance from the S_1 was initially 1 wavelength further than the distance from S_2. If the wavelength is halved the difference in the two path lengths is now 2λ.

This will still result in constructive interference at this point, for a local maximum.

$\therefore$ **Maximum (ANS)**

2025 NHT Question 12a, 3 marks

The atom requires 10.2 eV to change from the ground state to the first excited level.

Use $E = \frac{hc}{\lambda}$, to solve for λ.

$$\therefore 10.2 = \frac{4.14\times10^{-15}\times3\times10^{8}}{\lambda}$$

$$\therefore \lambda = \frac{4.14\times10^{-15}\times3\times10^{8}}{10.2}$$

$\therefore \lambda = 1.218 \times 10^{-7}$ m

$\therefore \lambda = 121.8 \times 10^{-9}$ m

$\therefore$ **λ = 122 nm (ANS)**

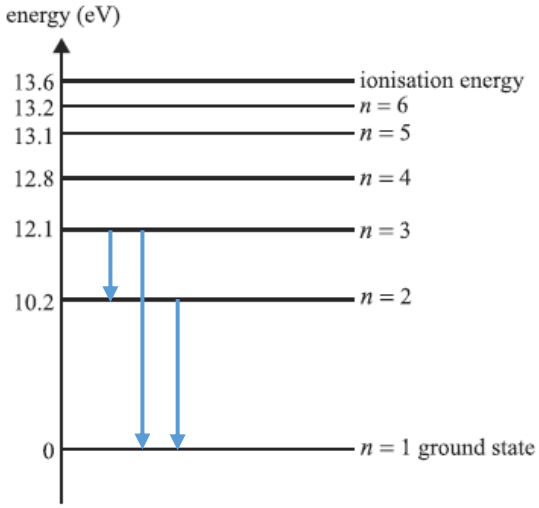
2025 NHT Question 12b, 2 marks

The momentum of a photon is given by $p = \frac{h}{\lambda}$

$$\therefore p = \frac{6.63\times10^{-34}}{103\times10^{-9}}$$

$\therefore$ **$p = 6.44 \times 10^{-27}$ kg m s^{-1} (ANS)**

2025 NHT Question 12c, 2 marks



2025 NHT Question 13, 2 marks

Each GPS satellite continuously transmits a signal containing its location and the precise time the signal was sent. A GPS receiver on Earth picks up signals from multiple satellites. The receiver has its own local clock for comparison. By comparing the time the signals were sent and received, the receiver calculates how far away each satellite is. Using signals from at least four satellites, the receiver can determine its precise location.

Because an observer on the ground sees the clocks in the satellites in motion relative to them, they will measure a dilated time. Therefore the rates of the clocks in the GPS satellites are adjusted so that the time signals received on Earth are accurate in the IRF of an observer on Earth.

2025 NHT Question 14, 4 marks

Observation 3 was not explained by the wave model.

In the particle model the energy of the incident particles (photons) depends on frequency, given by $E = hf$. Each photon interacts with one electron.

The energy of the emitted electrons is given by $KE = hf - \phi$, where ϕ is the work function of the metal. As the work function is a constant for each metal, the energy of the emitted electron is a function of the initial photon energy, i.e. its frequency.

In the particle model changing the intensity of the light varies the number of photons but not their energy. Therefore, the energy of the emitted electrons does not change, only the number of electrons that are emitted changes.

Whereas the wave model links the energy of the emitted electrons with the amplitude of the wave.

2025 NHT Question 15, 2 marks

The double-slit experiment can be performed using electrons, The electrons create an interference pattern of fringes which is characteristic of waves. The interference pattern implies that individual particles are somehow interfering with themselves, a behaviour associated with waves.

The behaviour of individual particles is probabilistic and influenced by the presence of other potential paths (slits).

2025 NHT Question 16, 2 marks

The power is the rate of energy loss per second.

Use $E = \Delta mc^2$ to find the mass that is being converted into energy.

$\therefore 1.52 \times 10^{27} = \Delta m \times (3.0 \times 10^8)^2$

$\therefore \Delta m = 1.68 \times 10^{10}$

$\therefore$ **1.69×10^{10} kg s^{-1} (ANS)**

2025 NHT Question 17a, 1 mark

Use the formula sheet to confirm that 1.90 TeV = 1.90×10^{12} eV.

To convert from eV to J, multiply by 1.6×10^{-19}.

$\therefore$ 1.90 TeV = $1.90 \times 10^{12} \times 1.6 \times 10^{-19}$.

$= 3.04 \times 10^{-7}$ J.

2025 NHT Question 17b, 2 marks

From classical mechanics,

$KE = \frac{1}{2}mv^2$

$\therefore 3.04 \times 10^{-7} = \frac{1}{2} \times 3.27 \times 10^{-25} \times v^2$

$\therefore v^2 = 1.86 \times 10^{18}$

$\therefore$ **$v = 1.36 \times 10^9$ m s^{-1} (ANS)**

2025 NHT Question 17b, 2 marks

The answer to part b does not conform to our present understanding of physics. The gold atom is travelling faster than the speed of light, which is considered impossible.

2025 NHT Question 17d, 2 marks

Use the relativistic formula for E_{total}.

$\therefore E_{total} = \gamma mc^2$

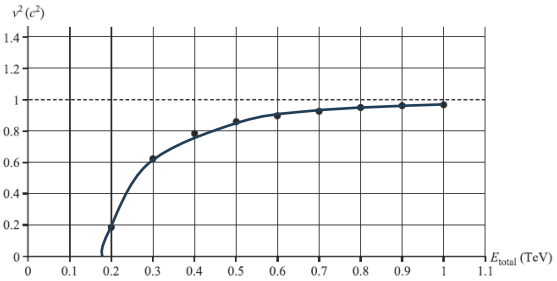
$3.04 \times 10^{-7} = \gamma \times 3.27 \times 10^{-25} \times (3.00 \times 10^8)^2$

$\therefore \gamma = 10.3$

2025 NHT Question 17e, 3 marks

Independent	the accelerating potential
Dependent	speed
Controlled	Gold ions

2025 NHT Question 17f i, 2 marks



2025 NHT Question 17f ii, 1 mark

The dashed line, is an asymptote. It represents the maximum speed '*c*' that the gold ions were not able to reach.

2025 NHT Question 17f iii, 2 marks

The horizontal intercept is 0.17 TeV. The total energy is given by $E_{total} = E_K + E_{rest}$.

Therefore when the KE = 0 (horizontal intercept) $E_{total} = E_{rest}$, therefore the intercept represents the relativistic rest energy of the gold ion.