**Raffles Institution**
**Year 5-6 Physics Department**

**2023 Year 5 H2 Physics Term 3 Common Test Solution**

**Section B**

**<u>Important points to note</u>**

1. Quantitative questions (i.e. questions that involve calculations)
   - Write the concept used to solve (e.g. By the conservation of energy) and clearly state where it is being applied (e.g. from the bottom to the top of the circular motion).
   - Write the equation in words and/or in symbols. Use standard symbols (e.g. *m* for mass). Refer to the list of key quantities, their symbols and units in the syllabus document for the standard symbols used for the A-level examinations. If other symbols are used and it is not clear what quantity they represent, students would need to define them clearly.
   - Substitue all numerical values into the equation in the appropriate units.
   - Make the quantity to be determined the subject of the equation.
   - Write the answer to more than 3 significant figures.
   - Write the final answer to the appropriate number of significant figures and with units.

2. Qualitative questions (i.e. 'explain', 'describe' questions that involve writing in continuous prose)
   - Read the question carefully to be clear of the objective of the question. The number of marks allocated are a good indication of the demands of the question.
   - Write in full but short sentences.
   - Points presented should follow a logical sequence until the objective of the question is met.
   - State the specific Physics concepts/principles/definitions used to support the explanation.
   - Use specific Physics terminologies.
   - Equations may be used to support the explanation. However, equations must be accompanied with word explanations.
   - Do not use abbrievations especially for the important concepts used in the explanation (e.g. by COE, COM, POM).
   - Spell out all quantities (e.g. force instead of *F*, mass instead of *m*). If there are too many quantities to define in a stated equation, then use standard symbols or the symbols that have already been defined in the question. However, for sybmols that could be ambiguous, students should spell these quantities out (e.g. if the explanation includes gravitational force and centripetal force, then using $F_G$ and $F_C$ is ambiguous if they are not defined).
   - Students should make use of the information/data given in the question to answer the question/deduce/draw conclusion as specificallly as possible (e.g. students should state that a quantity increases or decreases if the details given are sufficient to make this deduction, instead of just stating the quantity will not be the same or will change).
   - Read the answer again to ensure the objective of the question is met.

3. For 'show' questions, the marks allocated are for clear step-by-step working and explanations. No marks are given for the final answer since the answer is already given. Hence, all relevant working and substitutions have to be shown. If required to 'show' a numerical value, students are expected to calculate and write the answer to a larger number of significant figures than that required. This is then followed by writing the final answer to the correct number of significant figures required. (E.g. If the value to be shown is 3.45, students need to write 3.45112 first to show that they really did the calculations, before rounding off and writing the final answer as 3.45.)

4. For all quadratic equations, both solutions (positive and negative) have to be written down. Reject one of the solutions based on what the quantity is. (E.g. Reject negative answer for time.)

5. When dealing with equations involving vectors, always state the direction that is taken to be positive.

6. When applying the conservation of energy, state from which position to which position the conservation of energy is applied. Afterwhich, students are expected to write the conservation of energy as a word equation followed by the equation using symbols. The equations need to clearly show that all forms of initial energies is equal to all forms of final energies or equate the differences in all forms energies. All energy forms have to be included, even if that energy form is zero. Set that energy form to zero only when substituting in the numerical values to the equation.
   Accepted:
   - Applying conservation of energy from the bottom to the top of the circular motion,
     initial KE + initial GPE = final KE + final GPE
     $$\frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}mv_f^2 + mgh_f$$
     OR
     decrease in KE = increase in GPE
     $$\frac{1}{2}mv_i^2 - \frac{1}{2}mv_f^2 = mg\left(h_f - h_i\right)$$

   Not accepted:
   - Did not clearly show a difference in energies: $\frac{1}{2}mv^2 = mgh$ .
   - $\Delta KE = \Delta GPE$ is equivalent to: final KE – initial KE = final GPE – initial GPE which is incorrect. Correct equation should be $-\Delta KE = \Delta GPE$ . Note that $\Delta$ means 'change' which is specifically used to mean 'final – initial'.

7. Students should analyse and study these solutions well and learn/practise to present/craft their solutions/answers as given in these solutions. There is much room for improvement.

**Solutions**

**1** **(a)** It introduces systematic error to the measurements.

The diameter measurements will either be all smaller or all larger than the true value by a fixed amount which is the zero error that was unaccounted for.

**(b)** **(i)**

$$R = \rho \frac{L}{A}$$

$$\rho = \frac{RA}{L} = \frac{VA}{IL} = \frac{V\pi (d/2)^2}{IL} = \frac{\pi V d^2}{4IL}$$

$$= \frac{\pi (1.50)(0.23\times 10^{-3})^2}{4(0.32)(40.0\times 10^{-2})}$$

$$= 4.8688\times 10^{-7} = 4.87\times 10^{-7}\ \Omega\ \text{m}$$

*The correct expressions to determine *R* and *A* should be shown clearly.

**(ii)**

$$\rho = \frac{\pi V d^2}{4IL}$$

$$\frac{\Delta\rho}{\rho} = \frac{\Delta V}{V} + 2\frac{\Delta d}{d} + \frac{\Delta I}{I} + \frac{\Delta L}{L}$$

$$\Delta\rho = (4.8688\times 10^{-7})\left(\frac{0.01}{1.50} + 2\frac{0.01}{0.23} + \frac{0.01}{0.32} + \frac{0.1}{40.0}\right)$$

$$= 6.201\times 10^{-8} = 6\times 10^{-8}\ \Omega\ \text{m (1 s.f.)}$$

*Absolute uncertainty is always written to 1 s.f.

**(iii)** $\rho = (4.9\times 10^{-7}) \pm (0.6\times 10^{-7})\ \Omega\ \text{m}$

*The d.p. have to be the same after expressing both to the same order of magnitude.

**(c)** Accuracy is the degree of closeness between the mean value of the measurements, $4.9\times 10^{-7}\ \Omega\ \text{m}$, to the true value of $4.4\times 10^{-7}\ \Omega\ \text{m}$.
OR
Accuracy is whether the true value of $4.4\times 10^{-7}\ \Omega\ \text{m}$ falls within $4.3\times 10^{-7}\ \Omega\ \text{m}$ to $5.5\times 10^{-7}\ \Omega\ \text{m}$.

Precision refers to the degree of agreement between repeated measurements of the same quantity which is represented by the uncertainty $\Delta\rho = 0.6\times 10^{-7}\ \Omega\ \text{m}$.
OR
Precision is the spread of the measurements which is represented by the uncertainty $\Delta\rho = 0.6\times 10^{-7}\ \Omega\ \text{m}$.

*When distinguishing, reference to the definitions have to be made while bringing out the difference.
*No conclusion on the accuracy and precision is required by the question.
*Contradictions in the explanations are penalised.

**2** **(a)** **(i)** **1.** Taking direction downwards as positive,

$$s_y = u_y t + \frac{1}{2}a_y t^2$$

$$800 = \left(220\sin 15^\circ\right)t + \frac{1}{2}(9.81)t^2$$

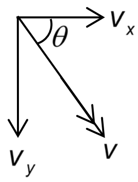
$$\frac{1}{2}(9.81)t^2 + \left(220\sin 15^\circ\right)t - 800 = 0$$

$$t = \frac{-220\sin 15^\circ \pm \sqrt{\left(220\sin 15^\circ\right)^2 - 4\left(\frac{9.81}{2}\right)\left(-800\right)}}{2\left(\frac{9.81}{2}\right)}$$

$$= 8.2238 \text{ or } -19.832 \text{ (NA)}$$

$$= 8.22 \text{ s}$$

**2.** $v_x = u_x = 220\cos 15^\circ = 212.504 \text{ m s}^{-1}$




$$v_y{}^2 = u_y{}^2 + 2a_y s_y$$

$$v_y = \sqrt{\left(220\sin 15^\circ\right)^2 + 2\left(9.81\right)\left(800\right)} = 137.616 \text{ m s}^{-1}$$

$$v = \sqrt{v_x{}^2 + v_y{}^2}$$

$$= \sqrt{\left(220\cos 15^\circ\right)^2 + \left(220\sin 15^\circ\right)^2 + 2\left(9.81\right)\left(800\right)}$$

$$= \sqrt{220^2\left(\cos^2 15^\circ + \sin^2 15^\circ\right) + 2\left(9.81\right)\left(800\right)}$$

$$= 253.172 = 253 \text{ m s}^{-1}$$

$$\theta = \tan^{-1}\frac{v_y}{v_x} = \tan^{-1}\frac{\sqrt{\left(220\sin 15^\circ\right)^2 + 2\left(9.81\right)\left(800\right)}}{220\cos 15^\circ} = 32.9268 = 32.9^\circ$$

magnitude = $253 \text{ m s}^{-1}$
direction = $32.9^\circ$ clockwise below the horizontal

OR (to determine speed)

increase in K.E. = decrease in G.P.E.

$$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = mg\left(h_i - h_f\right)$$

$$v = \sqrt{2g\left(h_i - h_f\right) + u^2} = \sqrt{2\left(9.81\right)\left(800\right) + \left(220\right)^2} = 253.172 = 253 \text{ m s}^{-1}$$

*Vague descriptions of the angle like 'from horizontal' or 'to horizontal' are not accepted unless it is accompanied by a diagram with angle correctly indicated.

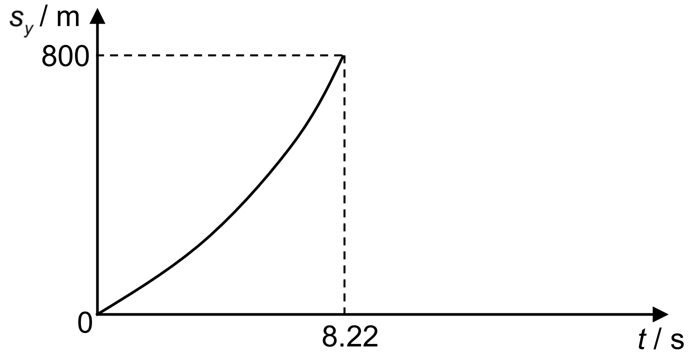
**(ii)** $s_x = u_x t$

$$= (220\cos 15^\circ)(8.22)$$

$$= 1746.78 = 1750 \text{ m}$$

The horizontal distance travelled by the bomb when it falls through a height of 8000 m is 1750 m. Since this is 250 m longer than 1500 m / not equal to 1500 m, the bomb will not land on the tank.

**(iii)**




*Quadratic curve with positive non-zero gradient at the origin.
*Values should be indicated on the graph wherever possible.

**(b)** At maximum height, the vertical displacements $s_y$ are the same for both projectiles and the vertical compononents of their velocities $v_y$ are both zero. From $v_y^2 = u_y^2 - 2gs_y$, the initial vertical velocities $u_y$ of both projectiles are also the same.

From $s_y = u_y t - \frac{1}{2}gt^2$, the time taken $t$ to reach maximum height, and consequently the time of flight, 2$t$, would be the same for both projectiles. Hence the projectiles will hit their targets at the same time.

OR

At maximum height, the vertical displacements are the same for both projectiles and both projectiles have the same initial vertical velocities (or the vertical components of their velocities are both zero at the highest point). Since both projectiles experience the same acceleration of free fall, they will also have the same time of flight. Hence the projectiles will hit their targets at the same time.

**3** **(a)** The mass of a body is the intrinsic property of a body which resists change in motion (or is a measure of inertia).
The weight of a body is a force experienced by a mass in a gravitational field (or is the product of its mass and the gravitational field strength / gravitational acceleration or is the gravitational force on a mass).
Hence mass is independent of location whereas weight is dependent on location.

*When distinguishing, reference to the definitions have to be made while bringing out the difference.
*Stating that mass is a scalar and weight is a vector or stating that their SI units are different is insufficient to distinguish the two quantities.

**(b)** A passenger standing in a lift experiences two forces, weight directed downwards and normal contact force directed upwards.
When the passenger has a downward acceleration, the normal contact force on the passenger is smaller than his weight.
With a smaller contact force, the passenger's apparent weight is smaller and the passenger feels lighter.

*The explanation has to focus on the forces acting on the passenger and not the lift. It is the passenger that feels lighter.

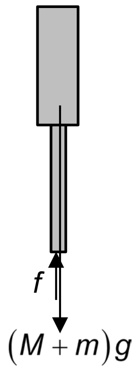
**(c)** **(i)** Pile was released from rest. By conservation of energy from the time pile driver was released to just before impact with the pile,

$$\text{increase in K.E.} = \text{decrease in G.P.E.}$$
$$\frac{1}{2}Mv_1^2 - 0 = Mg\left(h_i - h_f\right)$$
$$v_1 = \sqrt{2g\left(h_i - h_f\right)} = \sqrt{2 \times 9.81 \times 5.0} = 9.9045 = 9.90 \text{ m s}^{-1}$$

*Kinematics can also be used to solve this question.

**(ii)** Since the pile driver moves together with the pile after impact, by conservation of momentum,
$$Mv_1 = \left(M + m\right)v_2$$
$$v_2 = \frac{M}{M + m}v_1$$
$$= \frac{800}{800 + 200} \times 9.9045$$
$$= 7.9236 = 7.92 \text{ m s}^{-1}$$

**(iii)** The forces acting on the system (pile driver and pile) after impact are weight and soil resistance. Taking direction downwards as positive,




$$(M+m)g - f = (M+m)a$$

$$a = \frac{(M+m)g - f}{M+m}$$

$$= \frac{(800+200)\times 9.81 - (450\times 10^3)}{800+200}$$

$$= -440.19 \text{ m s}^{-2}$$

Using $v^2 = u^2 + 2as$, penetration depth

$$s = \frac{v^2 - u^2}{2a} = \frac{0 - 7.9236^2}{2\times(-440.19)} = 0.071314 = 0.0713 \text{ m}$$

OR

By conservation of energy from just after impact to when the pile driver and pile comes to rest,

decrease in G.P.E. $+$ decrease in K.E. $=$ work done against soil resistance

$$(M+m)gs + \left(\frac{1}{2}(M+m){v_2}^2 - 0\right) = Rs \quad \text{where } s \text{ is the penetration depth}$$

$$s = \frac{\frac{1}{2}(M+m){v_2}^2}{R - (M+m)g}$$

$$= \frac{\frac{1}{2}(800+200)(7.9236)^2}{(450\times 10^3) - (800+200)(9.81)}$$

$$= 0.071314 = 0.0713 \text{ m}$$

**4** **(a)** **(i)** The centre of gravity of a body is the point at which its entire weight / gravitational force (or the resultant of the distributed gravitational attraction on the body) appears to act.

*The centre of gravity of a body need not be on the body itself.
*The term 'gravity' is too vague and is not accepted.

**(ii)** The principle of moments states that for a body in equilibrium, the sum of all the clockwise moments about any axis must equal the sum of all the anticlockwise moments about the same axis.

*It has to be about 'any axis' and not 'the axis' which implies about one particular axis.
*The use of 'pivot' instead of 'axis' is not accepted as a pivot refers to a physical object (pin, shaft) about which the body turns.

**(iii)** For equilibrium, by the principle of moments
anticlockwise moments = clockwise moments about any point

Taking moments about A,

$$T_2 L \sin 60° = mg \frac{L}{2} \tan 30°$$

$$\frac{\sqrt{3}}{2} T_2 L = mg \frac{L}{2} \frac{\sqrt{3}}{3}$$

$$T_2 = \frac{mg}{3} = \frac{(2.5)(9.81)}{3} = 8.175 = 8.18 \text{ N}$$

For translational equilibrium in the vertical direction,

$$T_1 + T_2 = mg$$

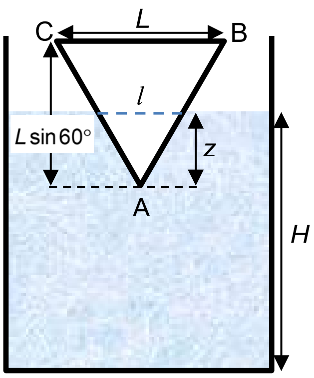
$$T_1 = mg - \frac{mg}{3} = \frac{2mg}{3} = \frac{2(2.5)(9.81)}{3} = 16.35 = 16.4 \text{ N}$$

*When applying the principle of moments, state the point about which this is applied.

**(iv)** Taking moments about C, the tension in the cable at A still needs to provide the clockwise moment to balance the same anticlockwise moment due to the weight in Fig. 4.2.
For the tension to be the smallest, the moment arm must be the longest. Moment arm is the longest when $\theta$ is 90°.

**(b) (i)** upthrust = weight of fluid displaced

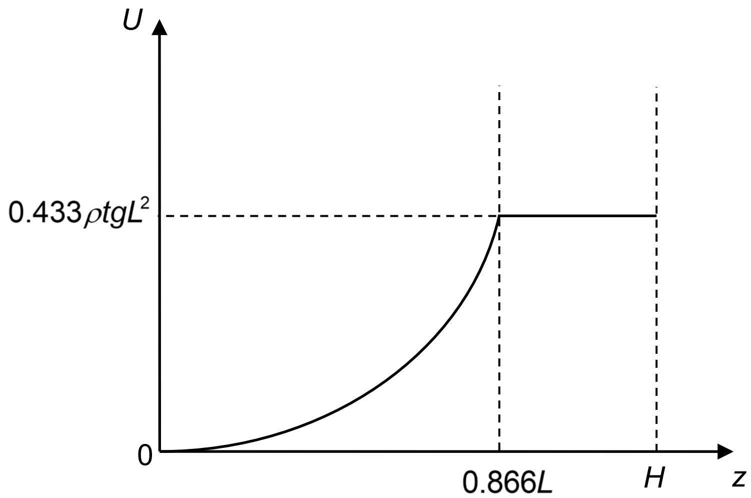
$$U = m_w g$$
$$= \rho_w V_w g$$
$$= \rho\left(\frac{1}{2} l z\right) t g$$
$$= \rho\left(\frac{1}{2} \times \frac{z}{L\sin 60^\circ} L \times z\right) t g$$
$$= 0.57735 \rho t g z^2$$
$$= 0.577 \rho t g z^2 \quad \text{(shown)}$$




Note: $l = \frac{z}{L\sin 60^\circ} L$ is from similar triangles or $l = \frac{2}{\tan 60^\circ} z$ from right angle triangle of height $z$.

*All steps in the working must be shown clearly especially for a 'show' question. Short phrases can be used to explain the derivation process.
*The application of Archimedes principle must be clear.
*The expression to determine the volume of water displaced must be shown clearly.

**(ii)**




$U = 0.577 \rho t g z^2$

maximum $U$ when $z = L\sin 60^\circ = 0.866L$

$U_{max} = 0.577 \rho t g \left(L \sin 60^\circ\right)^2 = 0.43275 \rho t g L^2 = 0.433 \rho t g L^2$

*Parabolic curve following $U = 0.577 \rho t g z^2$ from $z = 0$.
*Parabolic curve ends at $z = 0.866L$.
*Horizontal line for $z > 0.866L$ and at $U = U_{max} = 0.433 \rho t g L^2$.

**5** **(a)** Let $x$ be the maximum compression of the spring.
K.E. of the block is zero when released and at maximum compression.

By conservation of energy from when block is released to when compression of the spring is maximum,

increase in E.P.E. = decrease in G.P.E.

$$\frac{1}{2}kx^2 - 0 = mg\left(h_i - h_f\right)$$

$$\frac{1}{2}(250)x^2 = (0.200)(9.81)(0.40 + x)(\sin 30°)$$

$$125x^2 - 0.981x - 0.3924 = 0$$

$$x = \frac{-(-0.981) \pm \sqrt{(-0.981)^2 - 4(125)(-0.3924)}}{2(125)}$$

$$= 0.060090 \text{ or } -0.052242 \text{ (NA)}$$

$$= 0.0601 \text{ m}$$

**(b)** maximum speed occurs when resultant force on the block $F_{net} = 0$

Let $e$ be the compression of the spring at maximum speed.

$$mg\sin\theta = ke$$

$$e = \frac{mg\sin\theta}{k} = \frac{(0.200)(9.81)\sin 30°}{250} = 0.003924 \text{ m}$$

By conservation of energy from when block is released to when the kinetic energy of the block is maximum,

$$E_{inital} = E_{final}$$

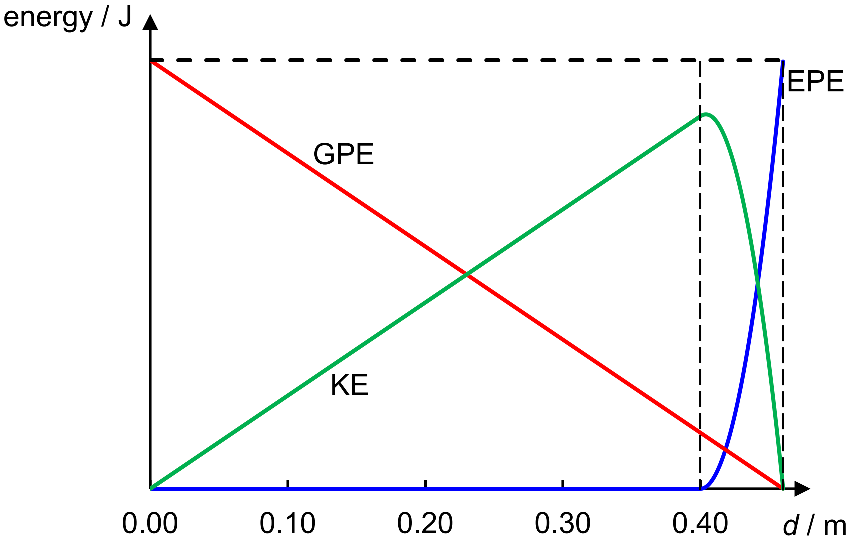
$$GPE_{\text{initial}} = KE_{final} + GPE_{final} + EPE_{final}$$

$$KE_{final} = mg(h_i - h_f) - \frac{1}{2}ke^2$$

$$= (0.200)(9.81)(\sin 30°)(0.40 + 0.003924) - \frac{1}{2}(250)(0.003924)^2$$

$$= 0.39432 = 0.394 \text{ J}$$

**(c)**




*GPE: Straight line with negative gradient and ends beyond $d = 0.40$ m.
*EPE: Quadratic curve for $d > 0.40$ m.
*KE: Straight line with positive gradient for $0 \le d \le 0.40$ m, curve for $d > 0.40$ m, maximum point after $d = 0.40$ m.
*Graphs add up to a constant total energy, graphs end at the same value of *d*.
*Start of GPE graph and end of EPE graph are at same height.
*Graphs are clearly labelled.

**(i)** $\text{GPE} = mgh_0 - mg(\text{decrease in height}) = mgh_0 - (mg\sin 30°)d$ where $h_0$ is the height when block is released.
Graph of GPE against *d* is a straight line.

**(ii)** EPE is only present after block moves 0.40 m down the slope and compresses the spring.

$$\text{EPE} = \frac{1}{2}k(d - 0.40)^2 = \frac{1}{2}k(d^2 - 0.80d + 0.16)$$

Graph of EPE against *d*, for $d > 0.40$ m, is a quadratic curve.

**(iii)** For $0 \le d \le 0.40$ m, only KE and GPE present.
Since GPE decreases linearly, KE increases linearly.

For $d > 0.40$ m, EPE increases quadratically while GPE continues to decrease linearly.
KE is such that the sum of the 3 energies is a constant. Hence KE is not linear.
Maximum KE occurs at $d = 0.40 + 0.003924 = 0.404$ m.

**6** **(a)** At point B,

$$N_B + W = \frac{mv_B^{\ 2}}{r}$$

$$N_B = \frac{mv_B^{\ 2}}{r} - mg$$

For the person to not fall off from the floor of the cage, the person must remain in contact with the floor.

For the person to stay in contact with the floor,

$$N_B \geq 0$$

$$\frac{mv_B^{\ 2}}{r} - mg \geq 0$$

$$v_B \geq \sqrt{rg} = \sqrt{(2.5)(9.81)} = 4.9523 \text{ m s}^{-1}$$

$$\text{minimum } v_B = 4.95 \text{ m s}^{-1}$$

*The equation formed from Newton's second law by considering all the forces acting on the person has to be written.
*Students need to explain why $N_B \geq 0$.
*The inequality sign in $N_B \geq 0$ should be used to show that the speed determined is indeed minimum as required by the question.

**(b)** By conservation of energy from point A to point B,
decrease in K.E. = increase in G.P.E.

$$\frac{1}{2}mv_A^2 - \frac{1}{2}mv_B^2 = mg\left(h_f - h_i\right)$$

$$\frac{1}{2}v_A^{\ 2} - \frac{1}{2}(4.95)^2 = 9.81(2 \times 2.5)$$

$$v_A = \sqrt{2 \times 9.81(2 \times 2.5) + (4.95)^2} = 11.0726 = 11.1 \text{ m s}^{-1}$$

**(c)** The two forces acting on the person are the weight *W* and the force *N* by the cage. For the person in circular motion, the resultant of *W* and *N* provides the centripetal (resultant) force that points towards the pivot. Let *m* and *v* be the mass and speed of the person respectively.

At point A, centripetal force is $N_A - W = \frac{mv_A^{\ 2}}{r}$. Hence, $\underline{N_A = \frac{mv_A^{\ 2}}{r} + W}$.

At point B, centripetal force is $N_B + W = \frac{mv_B^{\ 2}}{r}$. Hence, $\underline{N_B = \frac{mv_B^{\ 2}}{r} - W}$.

From the earlier parts, $\underline{v_A > v_B}$. Hence comparing the above equations, $\underline{N_A > N_B}$.

Since the force on the person by the cage is larger at point A, the person will feel <u>heavier at point A</u>.

*Speed is not constant. Hence, in using the equations to compare $N_A$ and $N_B$, a comparison between the speeds at point A and B needs to be made too.

**7** **(a)** Since gravitational force is attractive in nature, to bring a mass from infinity to a point in the gravitational field, the direction of the external force is opposite to the direction of displacement of the mass.

This results in negative work done per unit mass by the external force, which by definition gives negative gravitational potential.

**(b)** **(i)** Resultant field strength is the negative of the gradient of the graph in Fig. 7.1.
At point P, the gradient of the graph is zero, which means the resultant field strength at point P is zero.

$$g_M - g_E = 0$$

$$\frac{GM_M}{{r_M}^2} = \frac{GM_E}{{r_E}^2}$$

$$\frac{r_M}{r_E} = \sqrt{\frac{M_M}{M_E}}$$

$$r_M = \sqrt{\frac{M_M}{M_E}} \times r_E \quad \text{----- (1)}$$

$$r_E + r_M = 3.84 \times 10^8 \quad \text{----- (2)}$$

subst. (1) into (2),

$$r_E + \sqrt{\frac{M_M}{M_E}} \times r_E = 3.84 \times 10^8$$

$$r_E = \frac{3.84 \times 10^8}{1+\sqrt{\frac{M_M}{M_E}}} = \frac{3.84 \times 10^8}{1+\sqrt{\frac{7.35 \times 10^{22}}{5.98 \times 10^{24}}}}$$

$$= 3.4568 \times 10^8 = 3.46 \times 10^8 \text{ m (shown)}$$

**(ii)**

$$\phi_P = \phi_E + \phi_M$$

$$= \left(-\frac{GM_E}{r_E}\right) + \left(-\frac{GM_M}{r_M}\right)$$

$$= -\left(6.67 \times 10^{-11}\right)\left(\frac{5.98 \times 10^{24}}{3.46 \times 10^8} + \frac{7.35 \times 10^{22}}{3.84 \times 10^8 - 3.46 \times 10^8}\right)$$

$$= -1.2818 \times 10^6 = -1.28 \times 10^6 \text{ J kg}^{-1}$$

**(iii)** **1.** The theoretical minimum speed at which the rock will hit the Earth happens when the speed of the rock decreases to zero from the Moon to point P.

By conservation of energy from point P to the surface of the Earth,
increase in K.E. = decrease in G.P.E.

$$\frac{1}{2}mv^2 - 0 = m\phi_P - m\phi_E$$

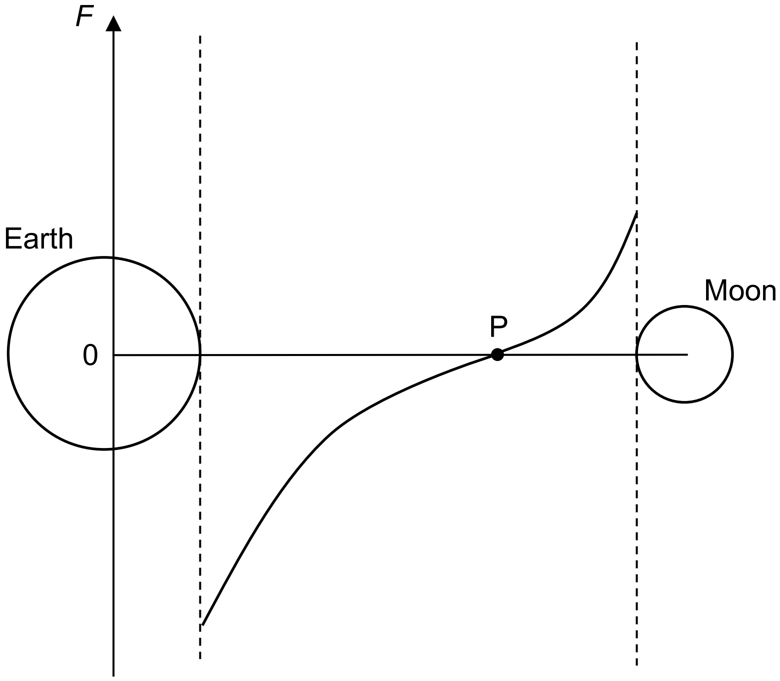
$$v = \sqrt{2\left(\phi_P - \phi_E\right)}$$

$$= \sqrt{2\left(\left(-1.28 \times 10^6\right) - \left(-62.3 \times 10^6\right)\right)}$$

$$= 11047 = 11000 \text{ m s}^{-1}$$

**2.** From point P to the surface of the Moon, the decrease in gravitational potential is smaller compared to from point P to Earth. This means that the decrease in gravitataional potential energy and hence the increase in the kinetic energy of the rock is smaller. The theoretical minimum speed upon reaching the Moon is thus smaller.

**3.**




$$F = mg = m\left(-\frac{d\phi}{dr}\right) = m(-\text{ potential gradient})$$

*Graph has to touch the dotted lines. The dotted lines are not asymptotes.
*Graph passes through $F = 0$ at point P with non-zero gradient. (Note that due to the large sizes of the Earth and the Moon, the gradient is very close to zero.)