**AHS 2023 S4 Physics Prelim Exam Paper 1 solutions**

| Q | Ans | Explanation |
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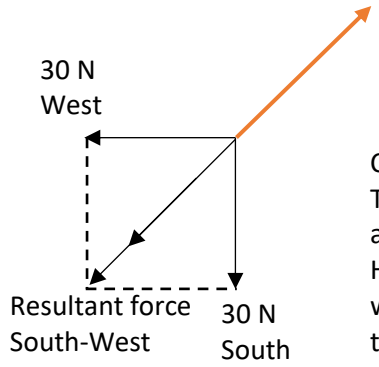
| 1 | C | diameter of Earth = $10 \times 10^6$ m = $1.0 \times 10^7$ m = $1.0 \times 10^4 \times 10^3$ m = $1.0 \times 10^4$ km<br>diameter of atom = $10 \times 10^{-9}$ m = $1.0 \times 10^{-1} \times 10^{-9}$ m = $1.0 \times 10^{-1}$ μm<br>length of football field = 100 m = $10 \times 10^1$ m |
| 2 | B | From P to Q to R → ¾ of a complete oscillation<br>period of oscillation = (1.5 / 3) x 4 = 2.0 s<br>number of oscillations in one minute = 60 / 2.0 = 30 |
| 3 | A |  <br>Combined effect of 2 horizontal forces = 30 N West<br>Together with the 30 N South force, the resultant force is acting approximately in the South-West direction.<br>Hence to keep the mass in equilibrium, an additional force with the same magnitude as the resultant force acting in the opposite direction to the resultant force is required. |
| 4 | D | Since velocity is positive throughout, there is no change in direction.<br>Option B and C can be eliminated.<br>Before opening his parachute, the velocity should not decrease for the parachutist. |
| 5 | B | Distance travelled from t = 20 s to t = 50 s = area under the graph<br>= (½ x 20 x (12.0 + 16.0)) + (½ x 10 x 12.0) = 340 m.<br><br>Average speed = total distance / total time<br>= 340 / 30 = 11.333…. = 11 m / s (2 s.f.) |
| 6 | A | There are no action-reaction pair as all the forces are acting on the same ladder. |
| 7 | D | The block of wood is moving to the left. Hence forces acting towards the left is positive.<br>First 5.0 s:<br>Using "F = ma", since a = 0 m / $s^2$, net force = 0 N<br>Thus, there must be friction of 20 N acting on the wood.<br>After 5.0 s:<br>Net force = F = $F_1$ – friction – $F_2$<br>= 20 N – 20 N – 10N<br>= - 10 N<br>(this means the net force is acting to the right, opposite to the motion of the wood)<br><br>From "F = ma", 'a' is negative when net force F is negative.<br>Negative 'a' means deceleration. |

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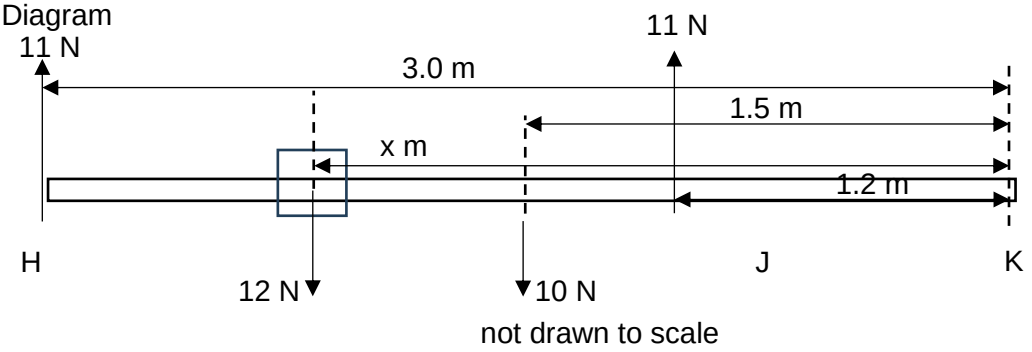
| 8 | C | Using " $\rho$ = m / V "<br>V of each ball bearing = m / $\rho$ = 18.0 / 9.0 = 2.0 $cm^3$<br>V of eight steel balls = 2.0 x 8 = 16.0 $cm^3$<br>Reading on measuring cylinder = 25.0 + 16.0 = 41.0 $cm^3$ |
| 9 | D | $d_4$ is perpendicular to the line of action of the force F. |
| 10 | D | Diagram<br>  <br><br>not drawn to scale<br>Taking moments about K,<br>sum of clockwise moments = sum of anti-clockwise moments<br>(11.0 x 3.0) + (11.0 x 1.2) = (12.0 x d) + (10.0 x 1.5)<br>d = 31.2 / 12.0 = 2.6 m |
| 11 | C | Pressure in the mercury column increases with depth. Atmospheric pressure is acting on the surface of the mercury. So the point is 10 cm above the surface of the mercury. |
| 12 | B | Liquid pressure is only affected by height of the liquid column above it, not on volume, cross-sectional area or shape of column. See textbook page 128. |
| 13 | B | liquid pressure difference in mercury column<br>= $\Delta h \rho g$ = (6.0 / 100) x 13600 x 10 = 8160 Pa<br>Since there is no change in atmospheric pressure, the difference in pressure for the two sides of the manometer must be the same.<br><br>Using pressure difference = $\Delta h \rho g$<br>816 0 = h x 1000 x 10<br>h = 0.82 m<br>Or: 6.0 cm x 13.6 = 0.816 ≈ 0.82 m (because mercury is 13.6 times denser than water |
| 14 | B | Total work done = work done against friction + work done against gravity + $E_K$ gained<br>F x d = (f x d) + (mgh) + $E_K$ gained<br>15 x 12 = (4 x 12) + (2.0 x 10 x 5.0) + $E_K$ gained<br>$E_K$ gained = 32<br>½ m $v_Q^2$ - ½ m $v_P^2$ = 32<br>2.0 x $v_Q^2$ – 2.0 x $2.0^2$ = 64<br>$v_Q^2$ = 36 ➔ $v_Q$ = 6.0 m/s |

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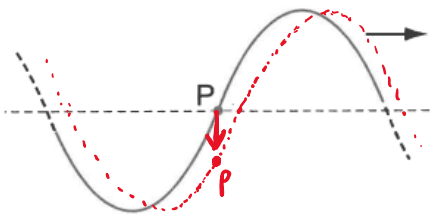
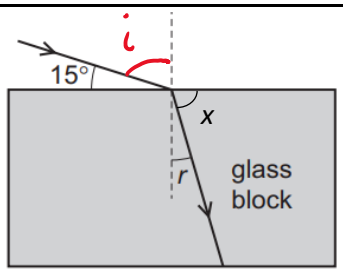
| | | OR :<br>$E_K$ at the start + Total work done = $E_P$ at the end + $E_K$ at the end + work done against friction<br>$(½ m v_P^2) + (F \times d) = (mgh) + (½ m v_Q^2) + (f \times d)$<br>$(½ \times 2.0 \times 2.0^2) + (15 \times 12) = (2.0 \times 10 \times 5.0) + (½ \times 2.0 \times v_Q^2) + (4 \times 12)$<br>$4 + 180 = 100 + v_Q^2 + 48$<br>$v_Q^2 = 36 \rightarrow v_Q = 6.0$ m/s |
| 15 | A | Power = Work Done / time (where work done is measured in J and time in s, hence J / s is equivalent to the unit of watt W.<br>kW h is a measure of energy, not power. |
| 16 | C | Chemical potential energy, Elastic potential energy, Gravitational potential energy |
| 17 | A | As they are made of the same material, they have the same density in the shape of a solid block. But as they have different masses, they do not have the same inertia nor heat capacity.<br>Though they have the same temperature, only the average kinetic energy of the particles in both are the same. The total KE and total PE of the particles are not the same because Y has more particles (more mass). |
| 18 | D | This is similar to Brownian motion as the dust particles are light enough to be affected by the invisible air particles but large enough to be seen under bright light. |
| 19 | C | At a lower temperature, the average kinetic energy of the particles is lower.<br>Hence, to <u>maintain the same gas pressure</u>, the frequency of collision have to be greater than before. |
| 20 | B | εαΔθ<br>+ 6.00 mV → change of 100 °C (temperature difference 100 °C)<br>+ 8.40 mV → change of (100/6.00) x 8.40 = 140 °C (temperature difference 140 °C)<br><br>The refence point (fixed point) is the hot junction (steam point, not ice point),<br>Hence boiling point of propane = 100 – 140 = - 40 °C |
| 21 | B |  |
| 22 | D | angle of incidence i = 90° – 15° = 75°<br>using Snell's Law, n = sin i / sin r<br>1.5 = sin 75° / sin r<br>angle of refraction r = 40°<br>x = 90 – r = 50°<br>  |

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| 23 | C | Critical angle is the angle of incidence in the optically denser medium for which the angle of refraction in the optically less dens medium is $90^o$. |
| 24 | D | Rays A and B are wrong because they diverge away.<br>Ray C is wrong because it did not bend. |
| 25 | C | Remember the EM spectrum song? |
| 26 | A | higher-pitched → higher frequency (lower period)<br>same loudness → same amplitude. |
| 27 | A | v = 2d / t (because echo travels to and fro), so d = vt / 2<br>depth of seabed, $d_1$ = 1500 x 1.0 / 2 = 750 m<br>distance of whale from the surface, $d_2$ = 1500 x 0.60 / 2 = 450 m<br>distance of whale above the seabed = 750 – 450 = 300 m<br>(Note: The thickness of a whale is only a few metres, which is only a small percentage of the answer. Hence it can be ignored.) |
| 28 | C | There is an electric field due to the charge in the plastic ball. There is Earth's gravitational field as well. |
| 29 | A | The ball is neutral, which is represented by no charges on the ball. |
| 30 | D | p.d. = work done / charge<br>p.d. across a resistor = 12 / 4.0 = 3.0 V<br>Total p.d.across the 3 resistors = 3.0 x 3 = 9.0 V.<br>Hence e.m.f. of battery = 9.0 V. |
| 31 | D | Let cross-sectional areas of wire 1 and wire 2 be $A_1$ and $A_2$ respectively.<br>$A = \pi r^2 = \pi d^2 / 4$.<br>So when the diameter of wire 2 is 50% of wire 1, the cross-sectional area of wire 2 is 25% of wire 1 because of the square factor.<br>Hence $A_2 = 0.25\ A_1$<br>Proof:<br>$A_1 = \pi d^2 / 4 = \pi(0.30 \times 10^{-3})^2 / 4 = 7.0714 \times 10^{-8}\ m^2$<br>$A_2 = \pi(0.15 \times 10^{-3})^2 / 4 = 1.7679 \times 10^{-8}\ m^2 = 0.25\ A_1$<br>*So $A_2 = 0.25\ A_1$.*<br>*Moreover, length of wire 2 is 3 times the length of wire 1. So $L_2 = 3L_1$.*<br>*Using $R = \rho l / A$*<br>*$R_1 = \rho L_1 / A_1 = R$*<br>*$R_2 = \rho L_2 / A_2 = \rho(3L_1) / (0.25A_1) = 12\ \rho L_1 / A_1 = 12\ R$* |

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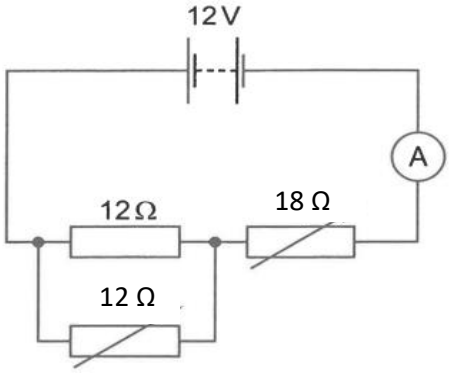
| 32 | B | $R = V / I$<br>When $V$ = 1.0 V, $R$ = 1.0 / 0 = very large<br>When $V$ = 2.0 V, $R$ = 2.0 / 11 x $10^{-3}$ = 182 Ω<br>When $V$ = 3.0 V, $R$ = 3.0 / 30 x $10^{-3}$ = 100 Ω<br>Hence the value of R decreases for values of $V$ above 1.4 V.<br>Although the line is straight after V = 1.4V, it does not pass through the origin. Hence the resistance is not constant. Moreover, the diode is a non-Ohmic conductor. |
| 33 | B | When the current is 0.50 A, the effective resistance R = V / I = 12 / 0.50 = 24 Ω.<br>When X = 18 Ω and Y = 12 Ω<br>Effective resistance<br>= $(1/12 + 1/12)^{-1}$ + 18<br>= 24 Ω<br>  |
| 34 | A | When the variable resistor is set at 0 Ω, the p.d. across it is 0 V.<br>When it is set at 1000 Ω, the p.d. across it is 1000 / 3000 x 12 = 4.0 V |
| 35 | B | When the live wire touches the metal casing, a short circuit is created. The current flowing through the circuit will be very large and it will cause the fuse to melt, hence switching off the circuit. |
| 36 | A | Bar PQ is a magnet while bar XY is not a magnet but it is a magnetic material since it is made of the same metal as bar PQ.<br>When XY is brought near to PQ, XY will be induced which leads to attraction but no repulsion. |
| 37 | B | When a charged particle moves, it creates a current. According to Fleming's left-hand rule, a force will be produced when the current and magnetic field is <u>perpendicular</u> to each other (motor effect). Hence, the charged particle will experience a force when it moves in direction Y but not X. |
| 38 | C | Wires P and R will attract each other while wires Q and R will repel each other. Therefore, wire R will experience 2 forces, one to the left (due to P) and one to the bottom of the page (due to Q). The resultant of these two forces is in the direction of C. |
| 39 | C | The galvanometer reading will be zero when there is no induced current in the solenoid. This only happens when the magnet is stationary in the solenoid. |
| 40 | D | Using Vs / Vp = Ns / Np<br>Vs = 20 / 300 x 230 = 15 V<br>Since 15 V is larger than the maximum rating of the lamp, the lamp will light up brightly first, then it blows due to overheating. |