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PHYSICS
Unit 3
Trial Examination

SOLUTIONS BOOK

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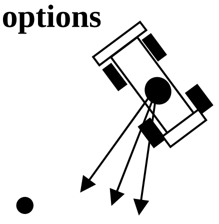
AREA 1 – MOTION IN ONE AND TWO DIMENSIONS

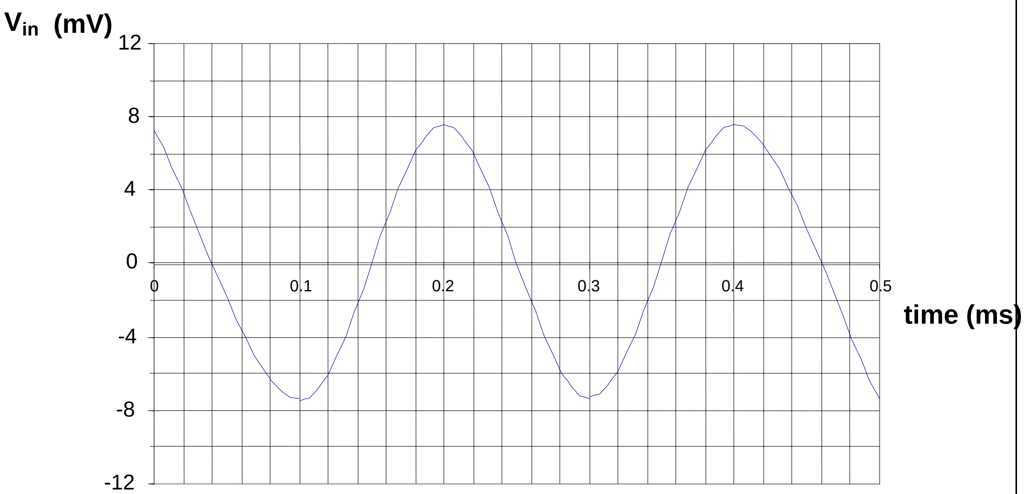
Q	Marks	Answer	Solution
1	**2**	**0.42 ms^{-1}**	$m_1u_1 + m_2u_2 = (m_1 + m_2)\ v$ since Anutja is initially moving vertically his u = 0 taking Anutja as m_1 and the skateboard as m_2 gives $45 \times 0 + 2.5 \times 8 = (45 + 2.5) \times v$ $0 + 20 = 47.5\ v$ $v = 20 \div 47.5 = 0.42\ ms^{-1}$
2	**2**	$KE_{initial} = ½\ m_1u_1^2 + ½\ m_2u_2^2 = 0 + ½ \times 2.5 \times 8^2 = 80$ J $KE_{final} = ½\ (m_1 + m_2)\ v^2 = ½\ (45 + 2.5) \times 0.42^2 = 4.2$ J Since $KE_{initial} \neq KE_{final}$ the collision is inelastic	
3	**2**	**YES**	to convert from ms^{-1} to kmh^{-1} multiply by 3.6 $\therefore\ 20\ ms^{-1} = 20 \times 3.6 = 72\ kmh^{-1}$
4	**3**	Note: cannot use W = F d since the F value changes $\therefore$ work done = area under the F – d graph = (eg) area of trapezium + area of triangle (other methods possible) $= ½\ (7000 + 6000) \times 30 + ½ \times 10 \times 6000 = 225\ 000$ J	
5	**3**	**1125 kg**	$W = \Delta KE = ½\ m\ (\Delta v)^2$ $225\ 000 = ½\ m \times 20^2$ $m = 225\ 000 \div 200 = 1125$ kg
6	**3**	**13.6 ms^{-1}**	Area under the force vs time graph = impulse = m Δv Area = $½\ (8 + 12) \times 6000 = 30\ 000$ Ns = m Δv $\therefore\ \Delta v = 30\ 000 \div 2200 = 13.6\ ms^{-1}$
7	**2**	**1130 N**	Taking forces on the trailer: $F_{net} = T - 250$ $400 \times 2.2 = T - 250$ $T = 880 + 250 = 1130$ N
8	**3**	**3.5 m**	For the vertical motion: u = 0, a = –10, s = –3, t = ? $s = ut + ½\ a\ t^2$ $-3 = 0 + ½ \times -10\ t^2 \rightarrow t = 0.775$ s for the horizontal motion: u = 4.5, a = 0, t =0.775, s = ? $s = ut + ½\ a\ t^2 = 4.5 \times 0.775 = 3.5$ m

Q	Marks	Answer	Solution
9	**3**	**22 N**	For the horizontal motion: u = 4.5, s = 22, a = 0, t = ? $s = ut + \frac{1}{2} a t^2$ $22 = 4.5\,t \rightarrow t = 4.89$ s Using this time in the vertical motion: u = 0, s = –3, t = 4.89, a = ? $s = ut + \frac{1}{2} at^2$ $-3 = 0 + \frac{1}{2} \times a \times 4.89^2 \rightarrow a = -0.25\ \text{ms}^{-2}$ $\therefore F_{vertical} = ma = 88 \times 0.25 = 22$ N down
10	**3**	**11 400 Nm^{-1}** **OR** **$1.14 \times 10^4\ \text{Nm}^{-1}$**	The spring potential energy at the bottom is converted into GPE at the top. Taking the lowest point as 0 height, makes the highest point 1.9 m above it. $\frac{1}{2} k x^2 = m g h$ $\frac{1}{2} \times k \times 0.4^2 = 48 \times 10 \times 1.9$ $0.08\,k = 912 \rightarrow k = 11\,400\ \text{Nm}^{-1}$
11	**2**	**2935 N**	$F_{net} = \frac{mv^2}{r} = 750 \times 60^2 \div 230 = 11\,739$ N $\therefore$ average force on each tyre = 11 739 ÷ 4 = 2935 N
12	**2**	**options** 	If the car was travelling at a constant speed the net force would be towards the centre of the corner. Since the car is braking and slowing down, there is a backward force component that shifts the net force to the rear of the centre of the corner. Any direction that is to the rear of the centre as shown
13	**3**	**570 N**	$F_{net} = \frac{mv^2}{r} = 76 \times 5^2 \div 10 = 190$ N down W = mg = 760 N down $\therefore$ force of road (which gives his apparent weight) $= W - F_{net}$ = 760 – 190 = 570 N up
14	**2**	**685 N**	$g = \frac{GM_E}{r^2}$ $= (6.67 \times 10^{-11} \times 5.98 \times 10^{24}) \div (6.37 \times 10^6 + 370\,000)^2$ $= 8.78\ \text{Nkg}^{-1}$ $\therefore$ weight of captain = mg = 78 × 8.78 = 685 N

Q	Marks	Answer	Solution
15	3	**7690 ms^{-1}**	$v = \sqrt{\frac{GM_E}{r}}$ = √((6.67 × 10^{-11} × 5.98 × 10^{24}) ÷ (6.37 × 10^6 + 370 000)) = 7693 ms^{-1} OR $a = v^2/r$ → $v = \sqrt{(gr)}$ = √(8.78 × (6.37 × 10^6 + 370 000)) = 7693 ms^{-1}

AREA 2 – ELECTRONICS AND PHOTONICS

Q	Marks	Answer	Solution
1	3	**A_1 = 0.8 A** **A_2 = 0.4 A** **A_3 = 0.4 A**	In a parallel circuit, each light globe gets the full 4.5 V and hence has the full 0.4 A through it. Hence A_2 and A_3 will be 0.4 A each. A_1 measures the sum of the currents in the two branches, so A_1 = 0.4 + 0.4 = 0.8 A. OR calculation of light globe resistance as 11.25 Ω and calculation to give A_1 = 0.8 A and ∴ $A_2 = A_3$ = 0.4 A.
2	2	**A_1 = 0.2 A** **A_2 = 0.2 A** **A_3 = 0.2 A**	In a series circuit, there is twice the resistance of the 'normal' circuit and for the same total voltage there will be half the 'normal' current. ∴ 0.2 A instead of 0.4 A. In a series circuit, all the ammeters will read the same. OR calculation of the total resistance as 11.25 + 11.25 = 22.5 Ω and the current is V/R = 4.5 ÷ 22.5 = 0.2 A each.
3	2	**1.8 W**	$P = VI = 4.5 \times 0.4 = 1.8$ W OR $P = I^2R = 0.4^2 \times 11.25 = 1.8$ W OR $P = V^2/R = 4.5^2 \div 11.25 = 1.8$ W
4	2	**0.4A**	The diode is reverse biased and will not conduct, so the current through the globe is the usual 0.4 A.
5	2	The characteristic has a negative gradient OR A rise in V_{in} gives a drop in V_{out} OR A drop in V_{in} gives a rise in V_{out}.	
6	2	**133**	gain = $\Delta V_{out} / \Delta V_{in}$ = 2 ÷ (15 × 10^{-3}) = 133 OR = 4 ÷ (30 × 10^{-3}) = 133

Q	Marks	Answer	Solution
7	**3**	To calculate the amplitude of V_{in} rearrange the gain equation to give: $\Delta V_{in} = \Delta V_{out} \div \text{gain} = 1 \div 133 = 0.0075$ or 7.5 mV Graph must be inverted with the same frequency. 	
8	**2**	**1**	For any amplifier the frequency of the input voltage is the same as the frequency of the output voltage, giving a ratio of 1.
9	**2**	**300 Ω**	From a light intensity of 3 lux, go up to the graph line and across to the resistance axis to give a reading of 300 Ω. Note: this is a log-log graph and hence the powers of ten on both axes.
10	**3**	**X**	As the sun sets, the light intensity drops. From the graph, as light intensity drops, resistance of the LDR increases. Hence the LDR's share of the 9 V will also increase and the variable resistor's share will decrease since the voltages must add to 9 V. Since the lights come on when the voltage drops, and this is what happens across the variable resistor and hence across X, this is where the switch should be. OR similar reasoning for what happens at sunrise. OR why it wouldn't work with the switch across Y.
11	**3**	**200 Ω**	The switching point is at 10 lux where the LDR has a resistance of 100 Ω and a 3 V drop across it. Therefore to have a 6 V share the variable resistor must be set at 200 Ω. (100 : 3 :: 200 : 6 OR 3 : 6 :: 100 : 200) OR use the voltage divider equation with V_{in} = 9 V, V_{out} = 6 V, R_1 = 100 Ω and solve for R_2.

Detailed study 1 – Einstein's special relativity

Q	Marks	Answer	Solution
1	2	C	The speed of light is constant for all observers. It still travels at 1.0c.
2	2	B	time = distance ÷ speed $= 6.0 \times 10^9 \div (3.0 \times 10^8) = 20$ s
3	2	B	The passenger is moving with the spacecraft, so the length she measures will not change.
4	2	D	The speed of light does not change with the position or speed of the observer.
5	2	A	$\gamma = (1 - 0.9^2)^{-1/2} = 2.294$
6	2	A	The speed and time data of the muons show they wouldn't actually reach the Earth's surface yet a large proportion of them do. This indicates their time of travel is shorter, hence it relates to time dilation.
7	2	C	$\gamma = (1 - 0.3^2)^{-1/2} = 1.048$ heavier $m = m_o \gamma$ $= 1.67 \times 10^{-27} \times 1.048 = 1.75 \times 10^{-27}$ kg
8	2	D	using relativistic physics: $E = \Delta m c^2 \rightarrow \Delta m = E \div c^2$ $= 8.4 \times 10^9 \times 1.6 \times 10^{-19} \div (3.0 \times 10^8)^2 = 1.49 \times 10^{-26}$ kg
9	2	A	using Newtonian physics: $E = ½ m v^2 \rightarrow v = \sqrt{(2E/m)}$ $v = \sqrt{((2 \times 100 \times 10^6 \times 1.6 \times 10^{-19}) \div (9.1 \times 10^{-31}))}$ $= 5.93 \times 10^9$ ms^{-1}
10	2	B	20 years is t_0 and 23.1 years is t $\rightarrow \gamma = t / t_0$ $\gamma = 23.1 \div 20 = 1.155 \rightarrow v = c (1 - 1/1.155^2)^{1/2} = 0.5c$
11	2	A	distance travelled = speed × slower time $d = v \times t_0 = 0.7c \times 2$ years = 1.4 light years
12	2	D	$v = (2 \times 10^8) \div (3 \times 10^8) = 0.6667$ c $\gamma = (1 - 0.6667^2)^{-1/2} = 1.3417$ heavier $m = m_0 \times \gamma$ $= 9.1 \times 10^{-31} \times 1.3417 = 1.22 \times 10^{-30}$ kg
13	2	D	$L = ½ L_0 \;\therefore\; \gamma = 2 \rightarrow v = c (1 - 1/2^2)^{1/2} = 0.87c$

Detailed study 2 – Materials and their use in structures

Q	Marks	Answer	Solution
1	**2**	**D**	The beam will bend which is a combination of compression along the top surface and tension along the bottom surface.
2	**2**	**D**	Taking torques about end X gives: 2500 N × 1.5 m = T sin 30° × 3 m → T = 2500 N or 2.5×10^3 N
3	**2**	**C**	Taking torques about the centre of the wheel and assuming the mass of rocks and the mass of the wheelbarrow (90 + 25 = 115 kg) acts at the centre of the handles gives: 1150 N × 0.55 m = $F_{lifting}$ × 1.1 m → $F_{lifting}$ = 575 N
4	**2**	**C**	The net force on the wheelbarrow will be zero. Total forces down = weight = 1150 N. ∴ total forces up = 1150 N made up of the 575 N lifting force and 575 N from the ground on the tyre.
5	**2**	**B**	$Y = \frac{\sigma}{\varepsilon} = \frac{F \times l_0}{A \times \Delta l}$ → $F = \frac{Y \times A \times \Delta l}{l}$ $F = \frac{1.0 \times 10^{11} \times 3.5 \times 10^{-4} \times 0.2 \times 10^{-3}}{0.75} = 9333$ N strain energy stored = area under Force v extension graph which would be a triangle, height being force (9333 N) and base being extension (0.2 mm) strain energy stored = ½ base × height = ½ × 0.2 × 10^{-3} × 9333 = 0.93 J OR strain energy stored = $\frac{Y \times A \times \Delta l^2}{2 \times l}$ sub in and solve
6	**2**	**D**	The above logic only works if the area under the graph is a triangle and hence still within the elastic limit of the glass.
7	**2**	**B**	Y = gradient = rise / run = 80 × 10^6 ÷ 0.002 = 4 × 10^{10} Pa

Q	Marks	Answer	Solution
8	**2**	**D**	From the point on the graph line with a strain of 0.003, rule a line with the same gradient as the linear section at the start of the graph. This should intercept the x-axis at a strain of 0.001. The material will have this much permanent deformation since the elastic limit was exceeded.
9	**2**	**D**	An X is commonly used to mark the point of fracture.
10	**2**	**A**	Cables can only be in tension. The cables all exert a downward component of force on the column which compresses the column.
11	**2**	**B**	The floor of the viewing deck will bend downwards making the top surface in tension and the bottom surface in compression. Concrete is weak in tension so the steel reinforcing should be placed along the top surface.
12	**2**	**B**	Since pillar B is in the centre of the beam, for the beam to remain stable there must be a downwards force **on the beam** at A of 850 N to match the weight force of the man. This means there will be an equal and opposite upwards force of 850 N **on pillar A**.
13	**2**	**C**	The shape of the arch is the property that gives it strength.

Detailed study 3 – Further electronics

Q	Marks	Answer	Solution
1	**2**	**C**	The first component after the input is a transformer.
2	**2**	**B**	The third component is a capacitor.
3	**2**	**A**	The last component is the voltage regulator.
4	**2**	**D**	The second component is the bridge rectifier.
5	**2**	**D**	The capacitor smooths the output of the bridge rectifier.
6	**2**	**D**	$V_{peak} = \sqrt{2} \times V_{rms} = \sqrt{2} \times 10 = 14.1$ V $V_{peak\text{-}to\text{-}peak} = 2 \times V_{peak} = 28.3$ V (or 28.2 if 14.1 is used)
7	**2**	**C**	$P = V I = 10 \times 1.5 = 15$ W (all values are RMS)
8	**2**	**C**	$I_{peak} = \sqrt{2} \times I_{rms} = \sqrt{2} \times 1.5 = 2.12$ A
9	**2**	**B**	A bridge rectifier gives a full-wave rectified output (∴ not A or C) Two diodes in the bridge rectifier take out two lots of 0.7 V leaving a peak voltage of 7.1 – 1.4 = 5.7 V peak.
10	**2**	**A**	The correct bridge rectifier circuit shows the arrows of the diode symbols "pointing" away from one of the output voltage terminals and towards the other output voltage terminal. A is the only circuit that shows this.
11	**2**	**B**	A zener diode works when reverse biased. The reverse bias section is where the graph is negative and the voltage is where the graph goes vertical.
12	**2**	**B**	$V_{ripple} = V_{max} - V_{min}$ $V_{ripple} = 50$ mV – 40 mV = 10 mV
13	**2**	**A**	The graph shows 3 cycles in 2 ms hence T (period) is 2/3 ms or 0.67×10^{-3} s. Hence f = 1/T = 1500 Hz