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PHYSICS
Unit 3
Trial Examination

SOLUTIONS BOOK

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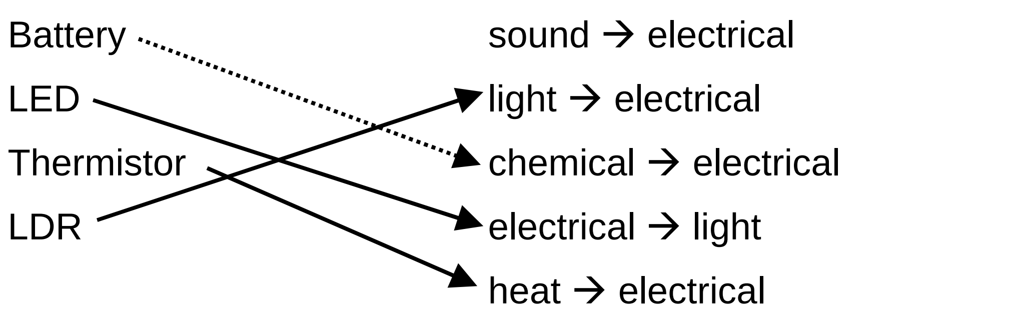
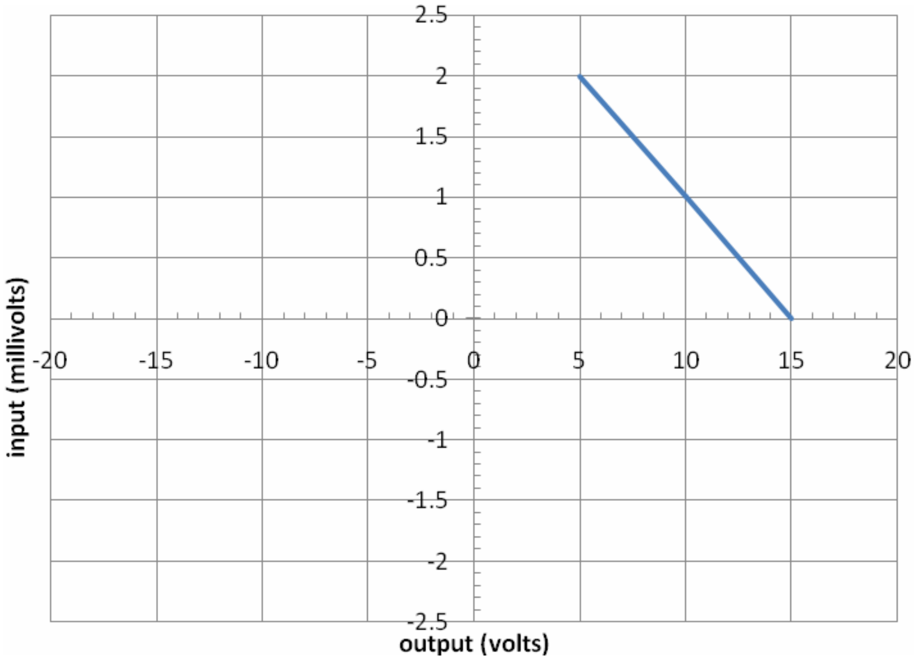
AREA 1 – MOTION IN ONE AND TWO DIMENSIONS

Q	Marks	Answer	Solution
1	**2**	**6 ms^{-2}**	From the graph, at t = 2 s, F_{net} = 6000 N F_{net} = ma → a = F_{net} ÷ m = 6000 ÷ 1000 = 6.0
2	**4**	**32 ms^{-1} (accept from 29 to 35 ms^{-1})**	Area under the force vs time graph = impulse = m Δv Area = ½ (2 × 6000) + ½ (6000 + 8000) × 2 + ½ (2 + 1) × 8000 = 6000 + 14000 + 12000 = 32000 (approx) = m Δv ∴ Δv = 32000 ÷ 1000 = 32 ms^{-1} ∴ since car starts from rest v = 32 ms^{-1}
3	**2**	F_{net} is negative in this time period which is in the opposite direction to its motion at t = 8 s. This can be explained by the car braking and slowing down.	
4	**2**	**D**	The negative F_{net} between 8 – 10 s only accounts for a change in velocity of –4 ms^{-1} ∴ the car is still going at a speed of 28 ms^{-1} at t = 10 s. OR The negative area under the graph is less than the positive area ∴ the car never stops and reverses in the opposite direction.
5	**2**	**9.8 ms^{-1}**	speed = distance ÷ time = ¼ × 2 π r ÷ t = ¼ × 2 π × 25 ÷ 4 = 9.8 ms^{-1}
6	**2**	**290 N**	$F_{net} = \frac{mv^2}{r}$ = 75 × 9.8^2 ÷ 25 = 289 N
7	**2**	**B**	Velocity in the middle of the turn is at a tangent to the circle and ∴ in the direction shown by arrow B.
8	**2**	**H**	The force exerted on the road by the bike is away from the centre of the circle and ∴ in the direction of arrow H
9	**3**	**311 N**	$F_{net} = \frac{mv^2}{r}$ = 70 × 5^2 ÷ 4.5 = 389 N F_{net} = W – N ∴ N = W – F_{net} = mg – 389 = 700 – 389 = 311 N

Q	Marks	Answer	Solution
10	**3**	**42 ms^{-1}**	For the vertical motion: u = 0, a = –10, s = –25, v = ? $v^2 = u^2 + 2as$ $v^2 = 0 + 2 \times -10 \times -25$ $v^2 = 500 \rightarrow v = -22.36$ i.e. 22.36 ms^{-1} down $\therefore$ using Pythag: impact speed$^2 = 36^2 + 22.36^2$ impact speed = 42.4 ms^{-1}
11	**3**	**80 m**	Using the vertical motion to calculate the time at impact v = u + at $-22.36 = 0 - 10t \rightarrow t = 2.236$ s Using this time in the horizontal motion: $s = ut + ½ at^2$ s = 36 × 2.236 + 0 = 80.496 m
12	**2**	**100 Nm^{-1}**	k = gradient = rise ÷ run = 80 ÷ 0.8 = 100
13	**3**	**19 ms^{-1}**	The spring potential energy is converted into kinetic. $½ k x^2 = ½ m v^2$ $½ \times 100 \times 0.3^2 = ½ \times 0.025 \times v^2$ $v^2 = 360 \rightarrow v = 18.97$ ms^{-1}
14	**3**	**91 minutes**	$\frac{r^3}{T^2} = \frac{GM_E}{4\pi^2}$ $T = \sqrt{\frac{r^3 4\pi^2}{GM_E}} = \sqrt{\frac{(6.37\times10^6 + 354000)^3 \times 4\pi^2}{6.67\times10^{-11} \times 5.98\times10^{24}}}$ = 5485 seconds = 5485 ÷ 60 = 91 minutes
15	**3**	**8.82 Nkg^{-1}**	The astronaut experiences apparent weightlessness because he is in free fall towards the Earth OR because there is force between him and the ISS. $g = \frac{GM_E}{r^2}$ $= (6.67 \times 10^{-11} \times 5.98 \times 10^{24}) \div (6.37 \times 10^6 + 354000)^2$ = 8.82

AREA 2 – ELECTRONICS AND PHOTONICS

Q	Marks	Answer	Solution
1	**2**	**A, C**	In A: 2 batteries across 2 globes is the same as one battery per globe, so that's normal brightness. In C: 2 batteries in parallel across 1 globe give the same voltage and current to the globe too so that's normal.
2	**2**	**B, D**	In both B and D more than one battery for one globe will produce a brighter light.
3	**2**	**30 V**	This is effectively a voltage divider circuit with the 50 V shared across the 2 kΩ and 3 kΩ resistors in the ratio 2:3 which means 20 V and 30 V respectively.
4	**3**	**5 lux**	$R_{total} = V \div I = 17 \div 0.068 = 250\ \Omega$ $R_{LDR} = 250 - 50 = 200\ \Omega$ from the graph, 200 Ω gives a light intensity of approximately 5 lux.
5	**3**		
6	**2**	Modulation is the process of carrying an electronic information signal with a carrier wave. OR Modulation is the process of changing an electronic information signal into a wave.	
7	**2**	Using a modulated carrier wave helps to distinguish (for transmitting and receiving) which radio signal is which since there are so many out there.	
8	**2**	**C**	Amplitude modulation carries the signal through the changing amplitude.
9	**2**	**D**	Frequency modulation carries the signal through the changing frequency.
10	**2**	**B**	A carrier wave is a standard waveform with no variation.
11	**2**	**200**	gain = $\Delta V_{out} / \Delta V_{in} = 2 \div (10 \times 10^{-3}) = 200$

<table>
<tr><th>Q</th><th>Marks</th><th>Answer</th><th>Solution</th></tr>
<tr><td>12</td><td>2</td><td colspan="2">

(Note: from the data supplied on the input and output graphs it is impossible to tell where the limits of the linear region are.)</td></tr>
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Detailed study 1 – Einstein's special relativity

Q	Marks	Answer	Solution
1	**2**	**D**	Maxwell's prediction for the speed of light definitely only depends on the electrical and magnetic properties of the medium.
2	**2**	**D**	The Michelson-Morley experiment attempted to measure the aether wind but **no** affect was found.
3	**2**	**D**	The scientist is moving with the spacecraft, so the mass he measures will not change.
4	**2**	**C**	$\gamma = (1 - 0.99^2)^{-1/2} = 7.0888$ $d_o = d \div \gamma = 4.62 \times 10^3 \div 7.0888 = 652$ m
5	**2**	**B**	$L = L_o/\gamma \rightarrow \gamma = L_o / L = 27 \div 20 = 1.35$ $v = c\,(1 - 1/\gamma^2)^{1/2} = 2.02 \times 10^8$ ms^{-1}
6	**2**	**A**	Newton knew speeds were relative. Adding the speeds gives a relative speed of 1.3c.
7	**2**	**C**	An observer on the Earth will observe the Voyager's true speed – 0.7*c*.
8	**2**	**C**	time in years = return distance in light years ÷ speed = (4.45 + 4.45) ÷ 0.866 = 10.28 years
9	**2**	**B**	$\gamma = (1 - 0.866^2)^{-1/2} = 2.0$ $t_o = t / \gamma = 10.28 \div 2 = 5.14$ years
10	**2**	**D**	$v = (2 \times 10^8) \div (3 \times 10^8) = 0.6667$ c $\gamma = (1 - 0.6667^2)^{-1/2} = 1.3417$ $m = m_o\,\gamma = 9.1 \times 10^{-31} \times 1.3417 = 1.22 \times 10^{-30}$ kg
11	**2**	**C**	total mass-energy = $m\,c^2$ but $m = \gamma\,m_o$ ∴ total mass-energy = $\gamma\,m_o\,c^2$
12	**2**	**B**	$\gamma = (1 - 0.3^2)^{-1/2} = 1.04828$ $p = m\,v = m_o\,\gamma\,v = 1.675 \times 10^{-27} \times 1.048 \times 0.3 \times 3 \times 10^8$ $= 1.580 \times 10^{-19}$ kgms^{-1}
13	**2**	**A**	$KE = (\gamma - 1)\,m_o\,c^2$ $= (1.04828 - 1) \times 1.675 \times 10^{-27} \times (3 \times 10^8)^2$ $= 7.278 \times 10^{-12}$ J

Detailed study 2 – Materials and their use in structures

Q	Marks	Answer	Solution
1	**2**	**B**	The cables pull down on the top of the flagpole, meaning it will be in compression.
2	**2**	**D**	Drawing a vector diagram of the cable forces and the resultant force, yields an equilateral triangle, therefore the force on the flagpole is 2×10^4 N downwards.
3	**2**	**B**	$F_1 d_1 = F_2 d_2$ $600 \times 6 = F \times 9 \rightarrow F = 400$ N
4	**2**	**C**	$Y = \frac{\sigma}{\varepsilon} = \frac{F \times l_0}{A \times \Delta l} \rightarrow F = \frac{Y \times A \times \Delta l}{l}$ $F = \frac{1.3\times10^{11} \times 0.4\times10^{-6} \times 2.5\times10^{-3}}{1.5} = 87$ N $\therefore$ mass = F ÷ g = 87 ÷ 10 = 8.7 kg
5	**2**	**C**	$\sigma = F / A \rightarrow A = F / \sigma = 75 \times 10 \times 3 \div (2.5 \times 10^8)$ $= 9 \times 10^{-6}$ m^2 $= \pi d^2 /4 \rightarrow d = 3.385$ mm
6	**2**	**D**	Composite materials contain more than one material.
7	**2**	**D**	If a member can be replaced by a string or rope and the structure remains static, that member is in tension, hence X and Y are in tension and Z is in compression.
8	**2**	**C**	As the floor sags the top surface will be in compression and the bottom surface will be in tension. Concrete is weak in tension so the steel reinforcing should be placed along the bottom surface.
9	**2**	**A**	Potential energy = area under a σ-ε graph × volume $= ½ \times 0.002 \times 80 \times 10^6 \times 2.5 \times 10^{-4} \times 2.0 = 40$ J
10	**2**	**C**	PE per unit volume = area under a σ-ε graph $= 20.5$ large boxes $\times 0.001 \times 10 \times 10^6 = 2.05 \times 10^5$ Jm^{-3}
11	**2**	**A**	The graph with the largest Young's modulus will have the steepest gradient.
12	**2**	**B**	The graph that is the most brittle will have no plastic region. (Note: Graph A has a small plastic region.)
13	**2**	**C**	The graph which is the toughest will have the greatest area under the graph.

Detailed study 3 – Further electronics

Q	Marks	Answer	Solution
1	**2**	**A**	$N_s / N_p = V_s / V_p$ $N_s = N_pV_s / V_p = 360 \times 12 \div 240 = 18$
2	**2**	**C**	$P_s = P_p = 0.05 \times 240 = 12$ W
3	**2**	**B**	$V_{peak} = \sqrt{2} \times V_{rms} = \sqrt{2} \times 12 = 16.97$ V
4	**2**	**D**	A bridge rectifier gives a full-wave rectified output.
5	**2**	**A**	One diode is positioned incorrectly (bottom right) so no output will be produced.
6	**2**	**A**	$V_{peak\text{-}to\text{-}peak} = 14$ cm × 50 mV cm^{-1} = 700 mV or 0.7 V
7	**2**	**C**	1 period = 5 cm × 10 ms cm^{-1} = 50 ms frequency = $1 \div (50 \times 10^{-3}) = 20$ Hz
8	**2**	**C**	The capacitor will be fully discharged in five time constants. $5\ \tau = 5\ R\ C \rightarrow R = 5\ \tau / 5\ C$ $R = 2.35 \div (5 \times 0.47 \times 10^{-6}) = 1 \times 10^{6}\ \Omega$ or 1 MΩ
9	**2**	**D**	$V_{ripple} = V_{max} - V_{min}$ V_{ripple} = 40 mV – 10 mV = 30 mV
10	**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 i.e. at –6 V
11	**2**	**D**	$I = P / V = 15 \div 10 = 1.5$ A
12	**2**	**B**	$P = I^2R \rightarrow R = P \div I^2 = 15 \div 1.5^2 = 6.7\ \Omega$ OR $P = V^2/R \rightarrow R = V^2 \div P = 10^2 \div 15 = 6.7\ \Omega$
13	**2**	**B**	The object circled is a fan and draws heat away from the underlying circuit.