June Practice 2

A GCE Physics B H557/01

Paper 1 Fundamentals of Physics

MARK SCHEME

Duration: 2 hours 15 minutes

MAXIMUM MARK 110

FINAL

This document consists of 13 pages

Section A: MCQs

Question			Answer	Marks	Guidance
1			D	1	
2			B	1	
3			C	1	
4			D	1	
5			D	1	
6			D	1	
7			A	1	
8			C	1	
9			B	1	
10			B	1	
11			D	1	
12			D	1	
13			A	1	
14			B	1	
15			B	1	
16			D	1	
17			D	1	
18			B	1	
19			C	1	
20			C	1	
21			D	1	
22			D	1	
23			B	1	
24			B	1	
25			D	1	
26			B	1	
27			C	1	
28			A	1	
29			B	1	
30			C	1	
			Total	30	

Section B

Question			Answer	Marks	Guidance
31	(a)		(- 6.67 x 10^{-11}x6.0 x 10^{24} / 6.4 x 10^{6}) ✓ = - 62.5(3) (MJ kg^{-1}) ✓	L L	evaluation **accept** 62.5 (MJ kg^{-1}) **RE** show that must have at least 3 SF
31	(b)		circular shape ✓ at 4 Earth radii from centre of Earth ✓	L M	judged by eye but must have all four axis intercepts equal **not** at 4 Earth radii from surface
31	(c)		g = 9.81 / 4^2 ✓ = 0.6(13) N kg^{-1} ✓	M M	method : use of inverse squared law OR $g \propto 1 / R^2$ **accept** full calculation at R = 4 x 6.4 x 10^6 m evaluation
			Total	**6**	

Question			Answer	Marks	Guidance
32	(a)		0.40 x 0.36 = M_{TOTAL} x 0.16 ✓ M_{TOTAL} = 0.90 kg ∴ M_{STAT} (= 0.90 – 0.40) = 0.50 kg ✓	L M	method must use / imply conservation of momentum
32	(b)		moving glider $F\Delta t = m\Delta v$ = 0.40 x [0.16 – 0.36] ✓ = - 0.08 (N s) ✓ OR state glider $m\Delta v$ = 0.50 x [0.16 – 0] = + 0.08 (N s)	M M	method must use / imply impulse = change in momentum evaluation for show that **ignore signs** ± magnitude only required
			Total	**4**	

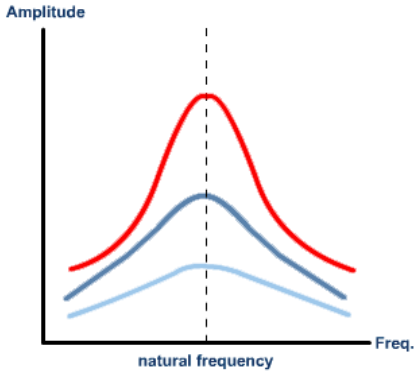
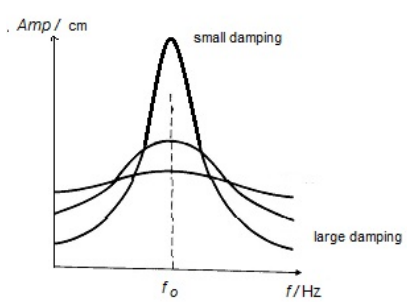
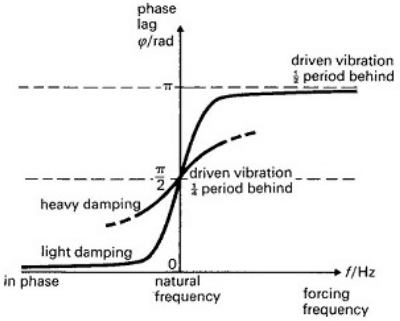
Question			Answer	Marks	Guidance
33	(a)		the charge remains constant during the interval Δt ✓	M	**accept** the current remains constant
33	(b)		using smaller Δt means ✓ better approximation to constant current during interval so overestimate of charge leaving during Δt is smaller error ✓	L H	state explain
33	(c)		ΔQ_{LOST} = 30 x 10/25 = 12 (mC) ✓ $Q_{REMAINING}$ = 30 – 12 = 18 (mC) ✓	L M	 **no ecf**
			Total	5	

Question			Answer	Marks	Guidance
34	(a)		sin r = sin 90° / 1.00029 ✓ r = 88.6(2°) ✓	S&C S&C	method **S&C** because such unusual context, application and precision evaluation
34	(b)		Sun will be seen above the horizon when actually below ✓ Because the light from below is refracted/bent so that it appears to come from above	M H	**accept** virtual image of Sun seen above its real position / Sun sets late **accept** diagram
34	(c)		ray would curve / bend downwards ✓ because it meet denser more refractive layers of Earth's atmosphere ✓	M H	**accept** it would curve, refracting more closer to Earth
			Total	6	

Question			Answer	Marks	Guidance
35	(a)		recognisable "fingerprint" lines are shifted towards red end of spectrum/longer wavelengths OR the emission / absorption lines are shifted towards red end of spectrum/longer wavelengths ✓ the increase $\Delta\lambda \propto \lambda$ OR as source recedes emitted waves are stretched out in space and so observed wavelength at Earth increases ✓	M H	**credit** any two separate points
35	(b)		Use of measurement and scaling to get a value for λ ✓ {720-656} c / 656 ✓ = 0.098 c ✓	L H H	Teachers should check measurements from their printed papers. This solution is based on scale of 36 mm ≡ 222 nm applied to any spectral line { red is best: shifted to ≈ 720 nm } **accept** their value of λ evaluation **accept** v in range 0.090 c to 0.110 c
			Total **Total section B**	**5** **26**	

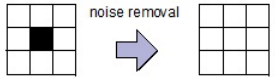
Section C

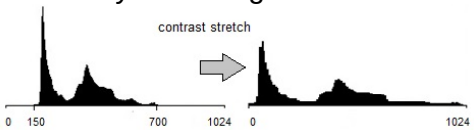
Question	Answer	Marks	Guidance
36*	**Level 3 (5–6 marks)** Marshals argument in a clear manner and includes clear explanation of three strands: • describing a resonance experiment • simple harmonic oscillator and meaning of resonance • typical results including the effect of damping *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Shows clear understanding of at least two of the three strands above to the argument **or** covers all three at a superficial manner and does not include enough indicative points for level 3. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Makes at least two independent points that are relevant to the argument but does not link them together and shows only superficial engagement with the argument. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be*	**HH** **MM** **LL**	**Indicative scientific points may include:** **resonance experiment mechanical or electrical oscillator** • labelled diagram of hacksaw oscillator driven by massive pendulum or electromagnet coil OR • mass on vertical spring driven by signal generator OR • resonant bottle driven by small speaker OR • LCR circuit driven by sig. gen. OR • Barton's pendulums • coupling by spring / magnetic force • varying driving frequency through natural frequency • measuring the amplitude or phase response • how to vary damping by air resistive force on card mechanically OR accept by resistance *R* in *LCR* circuit **resonance** • the large increase in A as $f_{DRIVER} \approx f_{NATURAL}$ • maximum energy transfer • analogy of child on swing driven by regular pushes • the phase relationship between driver and driven changing through resonance

Question			Answer	Marks	Guidance
			clear. **0 marks** No response or no response worthy of credit 		**typical results including the effect of damping** • graphs or description of response curve • typical resonance peak curves • broadening and lowering of peak due to damping • $\pi/2$ phase shift at resonance driver leading driven • in phase at lower f or out of phase at higher f • effect of damping on steepness of phase transition  
			Total	**6**	

Question			Answer	Marks	Guidance
37	(a)		gravitational E_P gained = elastic E_P in spring ✓ $h = Fx / [2mg] = 18 \times 0.25 / [2 \times 0.030 \times 9.81]$ ✓ = 7.7 (m) ✓	L M M	principle make conservation of energy clear **accept** correct ref to E_k or to work done **accept** $mgh = (\frac{1}{2} mv^2) = \frac{1}{2} Fx$ evaluation
37	(b)		spring contains some E_k at point of launch / some E_k of rocket transferred to air by air resistance / friction against walls of tube results in temperature increase ✓ So less energy transferred to E_P and so height less ✓	L L	**not** just all energy is not transferred **must** identify the energy transfer **accept** work done against air resistance.
37	(c)		EITHER ball bearing reaches higher ✓ because smaller surface area / less air resistance / less energy transferred to air by air resistance ✓ OR lower because larger surface area / less streamlined ✓ more air resistance /more energy transferred or work done against air resistance ✓	M M	**ignore** has same launch velocity
			Total	**7**	

Question			Answer	Marks	Guidance
38	(a)	(i)	to create a metal resistor of reasonable resistance in a small sized device ✓	L	**accept** to get a long length / small x-sectional area in a compact device
38	(a)	(ii)	resistance of connecting leads / contact resistance ✓	L	**accept** contact / thermal e.m.f. offsets Ohmmeter reading **not** within the limits of experimental accuracy
38	(b)	(i)	sensitivity = $\Delta V / \Delta \varepsilon$ OR = 0.006 / 0.002 ✓ = 3.0 (V per unit strain) ✓	M H	method **accept** in numbers / gradient evaluation **allow** 1 mark for 0.030 **POT**
38	(b)	(ii)	*T* increases ρ and *R* ✓ *T* increases dimensions of wire ✓ *R* would decrease due to expansion alone because % increase in *L* is ½ % increase in *A* ($R \propto L / A$) ✓ fractional change in ρ K^{-1} ≈ strain OR fractional change *L* in the gauge so this effect could be important ✓ OR fractional change in ρ K^{-1} >> fractional change *L* K^{-1} so expansion is a less important temperature than change in ρ	L L S&C S&C	**not** just *T* affects ρ and *R* **accept** % increase in *A* is 2 x % increase in *L* ($R \propto L / A$) **accept** % expansion K^{-1} ≈ 1/100 % increase ρ K^{-1} so could be ignored to first approximation
38	(b)	(iii)	Fig. 37.4 ∝ line added of 2 x gradient of original ✓	M	**expect** line through {0, 3.000} and {0.2, 3.012}, gradient = 0.0060
			Total	9	

Question			Answer	Marks	Guidance
39	(a)	(i)	1024 x 1224 x 3 x 10 = 37.6 Mbits ✓	L	**accept** 38 Mbits
39	(a)	(ii)	$R_{EARTH} \equiv$ (45 mm /53 mm) x 1024 = 870 pixels ✓ 6.4 x 10^6 m / 870 pixels = 7.4 x 10^3 (m pixel $^{-1}$) ✓	L M	Teachers should check measurements from their printed papers. This solution is based on earth radius of 45 mm and image width 53 mm. evaluation **accept** in range {7.2 to 7.6} x 10^3 (m pixel^{-1})
39	(b)		**Level 3 (5–6 marks)** Clear description of the three strands: • noise reduction • changing contrast or brightness • edge detection **AND** Gives advantages and problems of image processing and explains why compressing the image is useful *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Describes at least two of the three strands above **OR** covers all three at a superficial manner. **AND** Gives an advantage **OR** problem of image processing **OR** explains why compressing the image is useful *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Makes at least two independent points that are relevant *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be*	S&C H M M	**Indicative scientific points may include:** **Noise reduction:** • smoothing, by replacing the pixel value with the median of the values of that pixel and its 8 neighbours • the median value of the nine is the middle one(s) when placed in rank order •  • filtered image is built up in new array so that original pixel values are always used for rank filter **Edge detection:** • enhance edges by subtracting average value of pixels neighbour's from each pixel. • Removes uniform areas of brightness and highlights places where gradient of brightness changes abruptly. **Changing contrast or brightness:** Example (with 10 bits, could be 8 bits) • 10 bits means 2^{10} = 1024 levels of brightness • increase brightness by increasing the value on each

Question			Answer	Marks	Guidance
			clear. **0 marks** No response or no response worthy of credit	**L** **L**	pixel by the same amount until brightest pixel in image coded 1024 • whole range of levels may not be used so increase contrast by stretching to cover full 0 to 1024 range  • {value-lowest} x 1024 / {highest – lowest} **Advantages and problems of image processing and why compressing image is useful** • minimizing the size in bytes of an image file without degrading the quality of the image to an unacceptable level. • large areas of one pixel value / colour coded by colour value followed by number of consecutive pixels in the row with that colour • noise or spurious artefacts can be introduced to image OR real artefacts removed • reduces the time / bandwidth required for image transmission • reduction in file size allows more images to be stored in a given amount of disk or memory space. **accept clearly labelled diagrams throughout**
39	**(c)**		(info = rate x time) = 340 bit s^{-1} x 24 x 3600 s / 8 ✓ = 3.7 (Mbytes) ✓	**L** **L**	method evaluation
			Total	**11**	

40	**(a)**		Lorentz force / Bqv supplies centripetal force ✓ $Bqv = mv^2 / r \rightarrow Bq = mv / r \rightarrow r = mv / Bq$ ✓	**L** **M**	**accept** Bqv force remains perpendicular to v and pulls path into a circle keeping speed constant, acceleration causing only a change in direction
40	**(b)**	**(i)**	$T = \pi r / v = \pi mv / Bqv = \pi m / Bq$ (independent of v) ✓	**M**	
40	**(b)**	**(ii)**	(faster protons go further but time to traverse dee remains constant so) accelerating frequency can remain constant✓	**H**	
40	**(b)**	**(iii)**	$f = 0.8 \times 1.6 \times 10^{-19} / \{2\pi \times 1.673 \times 10^{-27}\} = 12$ M(Hz) ✓	**L**	**accept** 12.17 MHz OR 1.217×10^7 Hz
40	**(b)**	**(iv)**	2 crossings per spiral loop OR 10 k eV per loop number of loops = 1.2 MeV / 10 keV = 120 ✓	**H** **H**	 evaluation Award 1 mark for correct method and evaluation using 5 keV
40	**(b)**	**(v)**	$\gamma = E_{TOTAL} / E_{REST} = \{940 + 1.2\}$ MeV / 940 MeV ✓ = 1.001(3) ≈ 1 so non-relativistic approach reasonable ✓	**M** **M**	method evaluation and conclusion **accept** is a small deviation from 1
			Total	**9**	

Question			Answer	Marks	Guidance
41	**(a)**	**(i)**	$kT = 1.4 \times 10^{-23} \times 10^{11} / \{1.6 \times 10^{-19}\}$ (eV) $= 8.75 \times 10^6$ eV (≈ 9 MeV) ✓	**L**	method and show that evaluation to 8.75 or 8.8 MeV **accept** 8.63 MeV using $k = 1.38 \times 10^{-23}$
41	**(a)**	**(ii)**	rest energy of electron or positron ≈ $9.11 \times 10^{-31} \times (3 \times 10^8)^2 / (1.6 \times 10^{-13})$ = 0.512 MeV OR pair = 1.02 MeV ✓ << 9 MeV	**H** **H**	

Question			Answer	Marks	Guidance
41	(a)	(iii)	but for proton or antiproton is ≈ 1000 MeV >> 9 MeV for a substantial proportion of photons to have sufficient energy the temperature needs to be higher / about x10 to x100 higher ✓	H	
41	(b)	(i)	mass created = $m_{NEUTRON} - m_{PROTON} + m_{ELECTRON}$ OR = {1.008665 - 1.007276 + 0.000549} u ✓ = 0.001938 u = 1.810 MeV ✓	M M	**accept** mass / energy of neutrino may be zero / negligible as standalone alternative for first mark
41	(b)	(ii)	As T falls $e^{-\frac{E}{kT}}$ gets smaller, the number of p with enough energy to become n reduces. so ratio of p to n increases. ✓ fraction of particles with activation energy to create neutrons = Boltzmann factor = $e^{-\frac{E}{kT}} = e^{-\frac{1.8}{8.8}}$ ✓ $e^{-0.209}$ = 0.812 (p : n = 1 / 0.812) ✓	H S & C S & C	method evaluation
41	(c)	(i)	mass released as binding energy = $m_{DEUTERON} - \{m_{PROTON} + m_{NEUTRON}\}$ = 0.002388 u ✓ = 0.002388 x 931.1 MeV / u = 2.2(2) MeV ✓	M M	Evaluation **accept** calculation of mass and use of $E = mc^2$ and conversion to MeV gives 2.23 MeV
41	(c)	(ii)	thermal energy of particles / photons will be ≈ 0.9 MeV but in the Boltzmann / Planck distribution tail there will be particles with 2.2 MeV energy to break deuterons apart ✓	S&C	**accept** alternative words or estimated calculations e.g. fraction with activation energy ≈ $e^{-\frac{2.2}{0.88}}$ = 0.082
			Total	**12**	
			Total section C **Total sections B & C**	**54** **80**	