Assessment Schedule – 2005

Scholarship Physics (93103)

A nine point marking scale (0-8) was used to assess Section B, Questions 1, 2, and 3.
A seven point marking scale (0-6) was used to assess Section A, Questions 1, 2, and 3 plus Section B, Questions 4 and 5.

SECTION A

Question	Typical evidence that will be awarded one mark (if applicable)	Typical evidence that will be awarded two marks	
1(a)		$\frac{mv^2}{r} = \frac{GmM}{r^2}$ and $v = \frac{2\pi r}{T}$ $\frac{m\left(\frac{2\pi r}{T}\right)^2}{r} = \frac{GmM}{r^2}$ $\frac{4\pi^2 r^3}{T^2} = GM$ and $\rho = \frac{M}{V}$ $\frac{4\pi^2 r^3}{T^2} = G\rho\frac{4}{3}\pi r^3$ $\frac{\pi}{T^2} = \frac{G\rho}{3}$ $T = \sqrt{\frac{3\pi}{G\rho}}$ Sufficient steps must be shown to award 2 marks.	2
1(b)		$T_{Earth} = \sqrt{\frac{3\pi}{6.67\times10^{-11}\times5500}}$ $T_{Earth} = 84\,\text{min}$ This is significantly less than 24 hours so the Earth is not close to disintegration.	2

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Question	Typical evidence that will be awarded one mark (if applicable)	Typical evidence that will be awarded two marks	
1(c)	ONE reason provided.	BOTH reasons provided. One reason involves the difference in the distance from the centre of the Earth between the two positions due to the equatorial bulge – this leads to a variation in the gravitational field strength. The equator is further away from the centre of the Earth than the poles leading to a difference of about 0.05 m s^{-2}. The second reason is due to the rotation of the Earth. The person on the equator experiences a centripetal acceleration. Given that the scales read the normal (or reaction) force N, in this case $N = m(g–a_c)$. Therefore there is a slight reduction (of the order of the first effect).	2

Question	Possible Evidence for $E = mc^2$ question	Possible Evidence for photoelectric question	
2	Recognition of binding energy graph (either words or graph) Mass deficit Fusion more favorable under certain conditions Possible problems with fusion Fission only possible for high atomic numbers Possible problems with fission Iron stability versus stability in general	Experimental evidence of the photoelectric effect Formal experimental procedure – stopping potential, factors to alter wavelength etc Problems with classical theory Comparison with models of Newton and Planck Einstein photon idea Potential well model	6

Marking scheme:

6 marks awarded to an essay that covers at least six major points.

4 marks awarded to an essay that covers at least four major points.

2 marks awarded to an essay that covers at least two major points.

Question	Typical evidence that will be awarded one mark (if applicable)	Typical evidence that will be awarded two marks	
3(a)		No external torque so angular momentum is conserved (mass of camera small so position of centre of mass effectively centre of satellite). $L = mvr$ initially $L_0 = mv_0r_0$ as L conserved $mvr = mv_0r_0$ $v = \frac{v_0r_0}{r}$	2
3(b)	Only ONE aspect covered.	BOTH aspects covered as below. **Aspect 1:** The tension provides the centripetal force $T = F_c = \frac{mv^2}{r}$ from before $v = \frac{v_0r_0}{r}$ $\Rightarrow T = \frac{mv_0^2r_0^2}{r^3}$ **Aspect 2 :** as $r \to 0$ the tension $\to \infty$. This is a $1/r^3$ relationship so the force required will increase rapidly as the camera moves towards the centre.	2
3(c)		$\Delta W = \Delta E$ Work done $= \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2$ $= \frac{m}{2}\left(\frac{v_0^2r_0^2}{R^2} - v_0^2\right)$ $= \frac{mv_0^2}{2R^2}\left(r_0^2 - R^2\right)$ **OR** integration can be used to solve this problem.	2

SECTION B:

Question	Typical evidence that will be awarded one mark (if applicable)	Typical evidence that will be awarded two marks	
1(a)		Initial momentum $= 2.20\times10^{4}\times1.25$ $= 2.75\times10^{4}\,\text{kg m s}^{-1}$ no external forces act so momentum conserved. $\therefore$ final momentum of wagon $= 2.75\times10^{4}\,\text{kg m s}^{-1}$ velocity of wagon $= \frac{p}{m} = \frac{2.75\times10^{4}\,\text{kg m s}^{-1}}{3.7\times10^{4}\,\text{kg}}$ $= 0.74\,\text{m s}^{-1}$	2
1(b)		If zero friction then momentum conserved. As the superphosphate falls out the mass of the wagon decreases. However, the velocity of the wagon doesn't increase as the falling phosphate has a horizontal velocity and therefore momentum. It is only when the phosphate hits the ground that it loses its momentum i.e. the wagon is losing mass and losing momentum but maintaining a constant velocity. (Alternative approach is to consider the net force in the x direction, which is zero and therefore the acceleration is zero.)	2
1(c)	Award 1 mark if used faster speed. Final answer will be closer to 1.1×10^{7} kg.	volume of wagon $= 1.5\times1.5\times$ length mass per wagon (assume full wagon) $= 1.5\times10^{4} = \rho V = 1.1\times10^{3}\times1.5\times1.5\times$ length $\therefore$ length $= 6.06\,\text{m}$ If moving at $0.74\,\text{m s}^{-1}$ time to fill 1 wagon $= \frac{d}{v} = \frac{6.06}{0.74} = 8.2\,\text{s}$ in one hour can fill n wagons $n = \frac{60\times60}{8.2} = 440$ wagons therefore mass per hour $= 440\times1.5\times10^{4}$ $= 6.6\times10^{6}\,\text{kg}$	2

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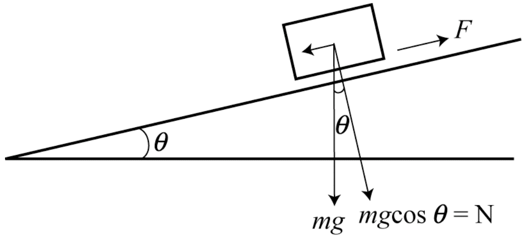
<tr><th>Question</th><th>Typical evidence that will be awarded one mark (if applicable)</th><th>Typical evidence that will be awarded two marks</th><th></th></tr>
<tr><td>1(d)</td><td></td><td>

Forces balanced for zero acceleration.
$N = mg\cos\theta$
$F = mg\sin\theta = \mu N$
$mg\sin\theta = \mu mg\cos\theta$
$\mu = \tan\theta$
$\theta = \tan^{-1}(0.005)$
$\theta = 0.29^\circ$</td><td>2</td></tr>
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2(a)	Candidate only calculates the additional "SHM" force or the weight force.	$\omega = \frac{2\pi}{T} = \frac{2g}{\sqrt{2}v} = \sqrt{2}\frac{g}{v}$ $a_{max} = \omega^2 A$ $F_{max} = ma_{max} = m\omega^2 A$ $F_{max} = 3.67 \times 2 \times \frac{9.8^2}{36^2} \times 4.56 = 2.48\,\text{N}$ But plane experiences an upward force of $3.67 \times 9.8\text{ N}$ just to keep it from falling, therefore F_{max}(total) = 38.45 N	2
2(b)	Candidate does not recognise that two altitudes are possible.	Period of oscillation is 16.3 seconds. 1.5 seconds is 0.0920 of a period – this corresponds to an angle of 33.1 degrees. So signal must be sent at $50 \pm 4.56\sin(33.1°) = 50 \pm 2.5\,\text{m}$	2
2(c)	1 mark for either 40 m s^{-1} or a correct assumption.	When the plane is overhead it is not moving towards or away from the microphone, so detected frequency = emitted frequency = 1000 Hz. Plane approaching $f' = f\frac{v_w}{v_w - v_s}$ $f' = 1133\,\text{Hz}$ $v_s = -\frac{fv_w}{f'} + v_w$ $v_s = -\frac{1000}{1133} \times 340 + 340 = 40\,\text{m s}^{-1}$ **OR** Plane receding $f' = f\frac{v_w}{v_w + v_s}$ $v_s = \frac{fv_w}{f'} - v_w$ $v_s = \frac{1000}{895} \times 340 - 340 = 40\,\text{m s}^{-1}$ **Assumptions:** Constant speed Zero wind speed Detector not moving The horizontal distance away from the detector is large enough that the velocity = component of the velocity towards the detector.	2

2(d)		The phugoid oscillations are vertical so Tom would need to measure the frequency when the plane is directly overhead. Maximum vertical velocity $= \omega A = 1.76\,\text{m s}^{-1}$. This would produce a very small frequency shift of about 5 Hz (this is a maximum shift so most of the time the value is smaller than this). Given the time window of opportunity that the plane is overhead and the small frequency shift, this would not be a very practical way to detect the phugoid oscillations.	2

3(a)	One mark for friction or right-hand wheel arguments.	The frictional force provides the centripetal force so it is towards the centre of the circle. The force on the right hand wheel is critical, as in the case of rolling the left hand wheel will lift off the road providing zero friction, and it is only the right hand wheel's frictional force that can keep the car on the road.	2
3(b)		Anticlockwise torques = clockwise torques $\tau_a = N \times \frac{t}{2}$ and $\tau_c = f \times h$ $f = \frac{mv^2}{r}$ $mg\frac{t}{2} = \frac{mv^2}{r} \times h$ $\Rightarrow \frac{t}{2h} = \frac{v^2}{rg}$	2
3(c)		If the centre of mass of the passengers is above C, then the more passengers there are the higher the total centre of mass will be and so the slower the car must be driven. Eg with a 50 m corner, v_{max} = 22.8 m/s unloaded, but if h increases by 20 cm, v_{max} = 20.4 m/s. If the gear is stowed in the back the effect on h will be much less than if it is stowed on the roof rack. The position of the passengers could be considered, eg moving around when cornering.	2
3(d)		It is an inverse relationship between rate of rolling and SSF. However, even the worst case SUV has a 0.03% rolling rate. Is this significant? These vehicles may have more chance of rolling but may be safer in collisions. However, it can be said that the shape of the above curve means that a small change in the SSF in the region of 1.0 to 1.2 would mean a large change in the rolling rate. An SSF of about 1.2 or greater seems optimal.	2

4(a)		Each bulb will have 12 V across it due to symmetry – given that this is the operating voltage of each bulb the resistances can be calculated by using R = V^2/P (the 20W bulbs have resistance = 7.2 ohms and the 40 W bulbs have resistance = 3.6 ohms). The majority of the current will take the path of least resistance so current will go from b to a. $I_1 \text{(top left hand branch)} = \frac{12}{7.2}$ and $I_2 \text{(bottom left hand branch)} = \frac{12}{3.6}$ $I_{ba} = -I_1 + I_2 = 1.67\text{ A}$	2
4(b)	1 mark for L_1 brighter and L_2 dimmer.	When switch S_2 is opened the same current exists in L_1 and L_2. The resistance of L_2 is unknown as we do not know the V-I characteristics of the bulb, but we can assume the value of the $L_2 < L_1$. This means L_1 has more voltage across it and therefore an increased current and brightness (it may blow). This then means that L_2 has less voltage than before and therefore less current so will be dimmer.	2
4(c)		We would need the V-I characteristics. Essentially its resistance values for all V and I values.	2

5(a)	1 mark for 4 A.	$R_T = 1.2 + 1.5 + 0.3 = 3.0\ \Omega$ $I = \frac{V}{R} = \frac{12}{3.0} = 4.0\ \text{A}$ $Q_1 = Q_2 = VC_T$ $V = 4.0 \times 2.7 = 10.8\ \text{V}$ $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$ $C_T = \frac{1}{\left(\frac{1}{0.05} + \frac{1}{0.02}\right)} = 0.014286\ \mu\text{F}$ $Q_1 = Q_2 = VC_T = 10.8 \times 0.014286\ \mu\text{F}$ $= 0.15\ \mu\text{C}$	2
5(b)	1 mark for unchanged current.	Current unchanged So $V_{C1} = V_{R1} = 1.5 \times 4.0$ $Q = CV$ $Q_1 = 6.0 \times 0.05\ \mu\text{C} = 0.3\ \mu\text{C}$ So $V_{C2} = V_{R2} = 1.2 \times 4.0$ $Q_2 = 4.8 \times 0.02\ \mu\text{C} = 0.096\ \mu\text{C}$	2
5(c)		The very top and bottom junctions are at the same potential due to symmetry so the capacitor between them can be ignored. So we are left with two sets of series capacitors each worth in total 0.5 microfarads. Finally we have three parallel branches $C_T = 0.5 + 0.5 + 1 = 2$ microfarads.	2

Judgement Statement

An aggregate mark of 54 from eight questions was used in Physics.
In 2005, candidates who achieved 40 marks or better were awarded outstanding scholarship and candidates who achieved 27-39 marks were awarded scholarship.