Name of the Student:_____
Max. Marks : 25 Marks **Time : 25 Minutes**

Mark Schemes

Q1.

Question Number	Acceptable Answer		Additional Guidance	Mark
(a)(i)	• Use of $V = \pi r^2 t$	(1)		7
	• Use of half resolution to calculate % uncertainty in d	(1)		
	• % uncertainty in area = 2 × (% uncertainty in d)	(1)		
	• Calculation of % uncertainty in t	(1)	Allow MP4 for use of full resolution if MP2 was withheld for not using half resolution	
	• % uncertainty in t added to % uncertainty in area	(1)		
	• $V = 5.94 \times 10^{-7}\text{m}^3$	(1)		
	• $\%\ U = 0.4\ \%$	(1)		
			Example of calculation $V = \pi\left(\frac{22.16 \times 10^{-3}\text{m}}{2}\right)^2 \times 1.54 \times 10^{-3}\text{m}$ $\therefore V = 5.94 \times 10^{-7}\text{m}^3$ $\%\ U = \left(2 \times \frac{0.005\text{ mm}}{22.16\text{ mm}} + \frac{0.005\text{ mm}}{1.54\text{ mm}}\right) \times 100\%$ $\%\ U = 0.36\ \%$	

(a)(ii)	**EITHER** • Use of $\rho = \frac{m}{v}$ (allow use of V from (i)) **(1)** • Calculation of % U in ρ **(1)** • Max density = 1.9×10^4 kg m^{-3} (ecf from (a)(i)) • 1.9×10^4 kg m^{-3} < 1.93×10^4 kg m^{-3} so coin not pure gold **(1)** **Or** comparison of calculated value of max density with density of gold and consistent conclusion **(1)** **OR** • Use of $\rho = \frac{m}{v}$ to calculate volume of a pure gold coin with mass 11.2g • Mass of pure gold coin = 11.5 g (ecf from (a)(i)) **(1)** • Use of half resolution to calculate max mass of coin being tested **(1)**	For MP2, allow use of resolution if use of half resolution has already been penalised in (a)(i) Allow a conclusion that states the values are similar so it might be gold MP4, allow "density of pure gold" for 1.93×10^4 kg m^{-3} For MP3, allow use of resolution if use of half resolution has already been penalised in (a)(i) MP4: allow "density of pure gold" for 1.93×10^4 kg m^{-3} Example of calculation $\rho = \frac{m}{V} = \frac{11.2 \times 10^{-3}\text{kg}}{5.94 \times 10^{-7}\text{m}^3}$ $= 1.89 \times 10^4$ kg m^{-3} $\%\ U = \frac{0.05\ g}{11.2\ g} \times 100\% + 0.36\%$ $= 0.81\ \%$ $\therefore$ range $= \pm 1.89 \times 10^4$ kg $\times 0.008$ $= \pm 152$ kg m^{-3} $\therefore$ max density $= 18900 + 150$ $= 19050$ kg m^{-3}	**4**

• 11.25 g < 11.5 g, so coin is not pure gold **Or** comparison of maximum value of mass of coin with mass pure gold coin and consistent conclusion. **(1)** **OR** • Use of $\rho = \frac{m}{v}$ to calculate volume of a pure gold coin with mass 11.2g **(1)** • Use of half resolution to calculate % U in mass (0.05/11.2 × 100% = 0.44 %), and hence calculated volume **(1)** • Find the *smallest* volume possible within uncertainty from part (i) **(1)** • $5.83 \times 10^{-7}\ m^3 < 5.91 \times 10^{-7}\ m^3$, so coin not pure gold **Or** comparison of minimum value of volume of coin from part i with maximum volume of pure gold coin and consistent conclusion. **(1)**	

Question Number	Acceptable Answer		Additional Guidance	Mark
(b)	**MAX 4** • Measure thickness of a stack of coins **Or** measure the mass of a stack of coins	(1)	MP1 accept measuring a number of coins side by side MP1 accept using a balance with a higher resolution	
	• (Uncertainty remains the same, so) % U is reduced [MP2 dependent on MP1	(1)	MP2 as this would reduce the uncertainty	
	• Determine diameter/mass/thickness by repeating measurement and calculating a mean	(1) (1)	MP4 dependent on MP3	
	• This reduces the effect of random errors	(1)	MP6 dependent on MP5	**4**
	• Check and correct for zero error on calipers or balance			
	• This reduced the effect of systematic error			

Q2.

Question Number	Acceptable answers		Additional guidance	Mark
(a)	• use of density = mass / volume	(1)	Example of calculation: $V = 1.0 \times 10^{13}$ kg ÷ 470 kg m^{-3} $= 2.13 \times 10^{10}$ m^3	
	• use of $V = 4/3\ \pi r^3$	(1)	$= 4/3\ \pi r^3$ $r = \sqrt[3]{(2.13 \times 10^{10}\ \text{m}^3 \times 3) \div 4\pi}$	
	• $r =$ 1720 m	(1)	= 1720 m	**(3)**

Question Number	Acceptable answers		Additional guidance	Mark
(b)	• use of $g = GM/r^2$	(1)	Example of calculation: $g = 6.67 \times 10^{-11}$ N m^2 kg^{-2} ×	
	• $g = 2.3 \times 10^{-4}$ N kg^{-1}	(1)	1.0×10^{13} kg / (1720 m)^2 $g = 2.25 \times 10^{-4}$ N kg^{-1}	**(2)**

Question Number	Acceptable answers	Additional guidance	Mark

Question Number	Acceptable answers	Additional guidance	Mark
(c)	• use of $s = \frac{1}{2} gt^2$ (1) • $s = 1.2 \times 10^3$ m (1)	Example of calculation: $s = 0.5 \times 2.25 \times 10^{-4}$ m s^{-2} $\times$ (3300 s)^2 $= 1.2 \times 10^3$ m	**(2)**

Question Number	Acceptable answers	Additional guidance	Mark
(d)	An explanation that makes reference to the following: • the calculated height is comparable with the radius (of asteroid) (1) • the field should be considered as radial rather than parallel, so the gravitational field strength is decreasing significantly for the probe (1) OR $g = GM/r^2$ (1) the change in r is comparable with the radius, so there will be a significant change in g • acceleration is less, so the actual height would be less (1)		**(3)**