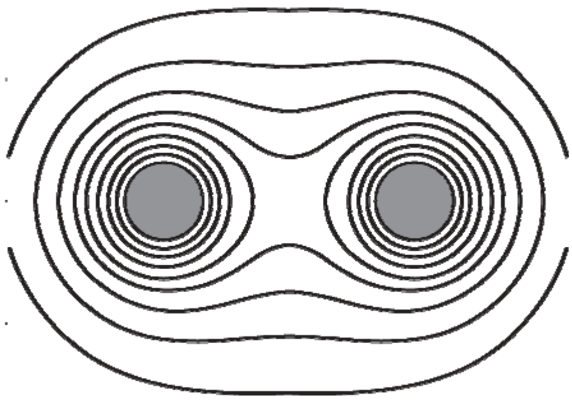
Mark scheme for Extension Worksheet – Topic 2, Worksheet 5

1 The work done per unit mass; to move (at a very small constant speed) a point small test mass from infinity to a point in a gravitational field. [2]

2 At a very large distance from the big mass the gravitational potential energy is zero; the work to move the mass from infinity to a point near the big mass is negative (since the force applied by the external agent on the mass is opposite to the direction of motion) and so the gravitational potential energy is negative. [2]

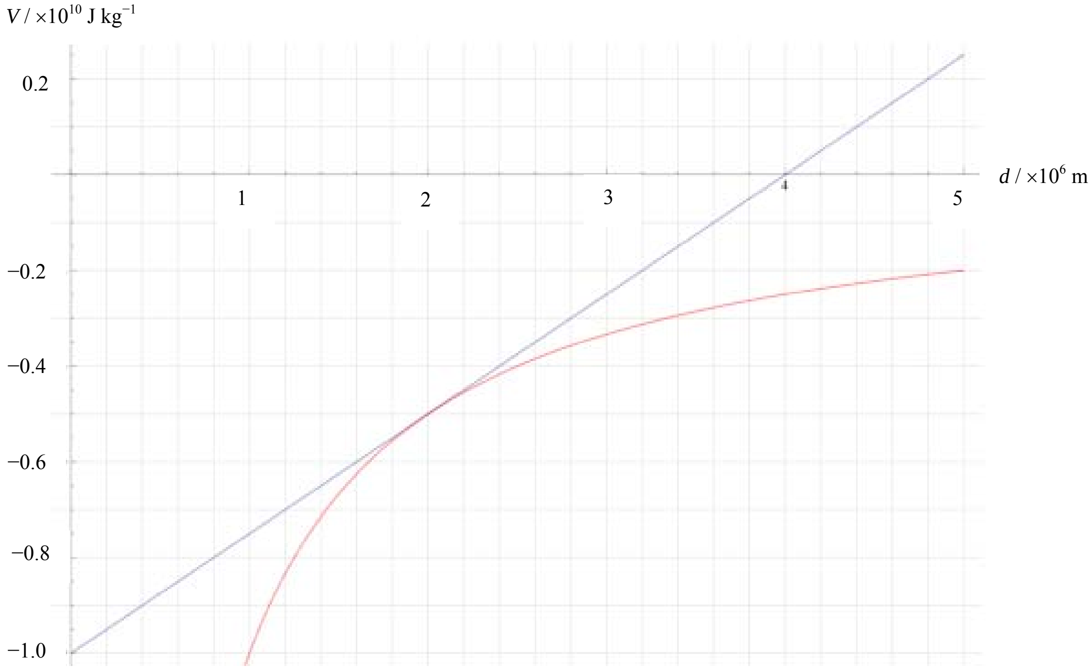
3 The work needed to move a mass m form one of the two points to the other is $W = m\Delta V$; but it also equals $W = F\Delta r = mg\Delta r$; equating gives the result. [2]

4 See diagram. Circles around each mass close to the mass; larger circles around both masses far from the masses.



[2]

5 **a** To find the gravitational field strength at a point we need to draw a tangent line on the potential–distance graph at the point of interest; The slope is $\frac{0-(-1.0\times10^{8})}{4.0\times10^{6}-0}=25$ and so $g=25\ \mathrm{N\,kg^{-1}}$.



[2]

b The difference in potential between the surface and the other point is $-0.50\times10^{8}-(2.55\times10^{8})=2.05\times10^{8}\ \mathrm{J\,kg^{-1}}$; and so the work done is $m\Delta V=350\times2.05\times10^{8}=7.2\times10^{10}\ \mathrm{J}$ [2]

c When in orbit with orbit radius r the kinetic energy is $\frac{1}{2}mv^{2}=\frac{GMm}{2r}=-\frac{1}{2}mV$; hence we must provide the kinetic energy i.e. $-\frac{1}{2}\times350\times(-0.50\times10^{8})=8.75\times10^{9}\ \mathrm{J}$ [2]

6 The potential energy of the mass at its present position is $-\frac{GMm}{a}-\frac{GMm}{a}=-\frac{2GMm}{a}$; when it moves very far away its total energy will be zero and so the required energy is $\frac{2GMm}{a}$ [2]