3 The masses of the Earth and the Moon each produce a gravitational field. The gravitational potentials at the Earth's and Moon's surfaces are -62.3×10^6 J kg^{-1} and -3.9×10^6 J kg^{-1} respectively. The mass of the Earth is M_E and the mass of the Moon is M_m. The distance between the centres of the Earth and Moon is *D*.

(a) Sketch a graph to show the variation with distance of the net gravitational potential for the region between the surfaces of the Earth and the Moon in **Fig.**

3.1. Label the vertical axis with the relevant quantities, units and numerical values.

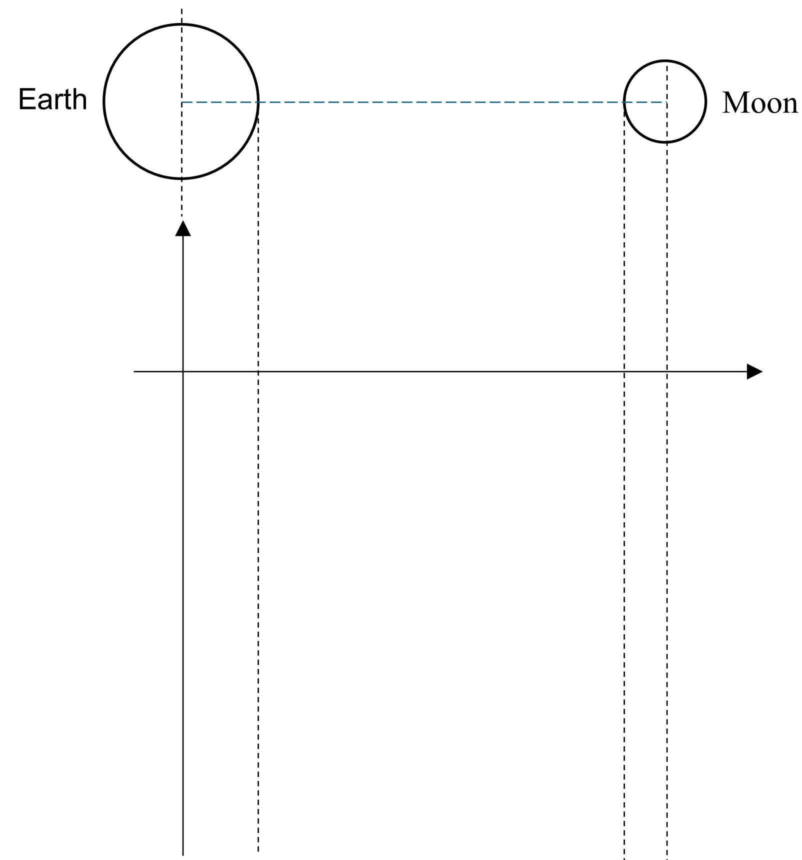

Fig. 3.1

[2]

(b) A 1000 kg satellite is launched from the Earth to the neutral point between the Earth and the Moon. It requires 6.1×10^{10} J in order to reach the neutral point.

(i) Explain what is meant by the neutral point. Indicate the position of the neutral point on **Fig. 3.1** with an "X".

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(ii) Determine the gravitational potential at the neutral point.

Gravitational potential = …………………………….. J kg^{-1} [2]

(b) Another 1000 kg satellite is launched from the Earth and has an orbital period *T* of 27.3 days about the Earth, the same as the orbital period of the Moon. This means that the Earth, satellite and Moon remain in a straight line always, with the satellite between the Earth and Moon.

(i) With respect to **Fig. 3.1**, explain whether this satellite is located on the left or right of the neutral point.

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(ii) The mass of the satellite is m. Write down an equation for the circular motion of the satellite about the Earth. The equation must include the masses of the satellite, the Earth and the Moon, the distances D and r where r is the distance from the centre of the Earth to the satellite, and the angular velocity ω of the satellite.