3 **(a)** By reference to the definition of gravitational potential, explain why gravitational potential is a negative quantity.

……………………………………………………………………………………................................

……………………………………………………………………………………....................... [2]

(b) Two stars A and B have their surfaces separated by a distance of 1.4×10^{12} m, as illustrated in Fig. 3.1.
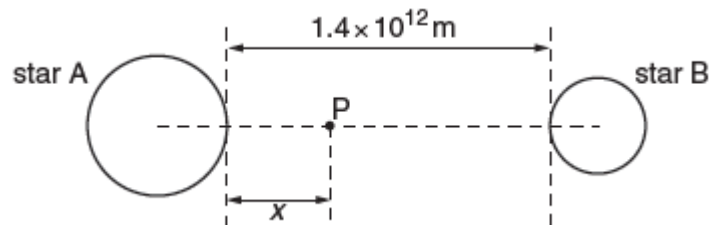

Fig. 3.1

Point P lies on the line joining the centres of the two stars. The distance x of point P from the surface of star A may be varied.

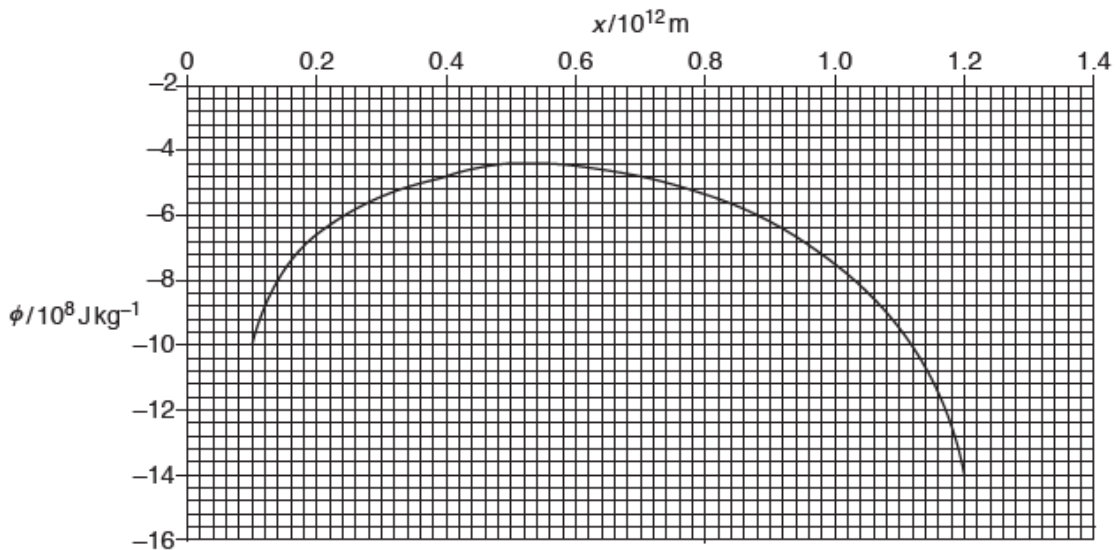The variation with distance x of the gravitational potential ϕ at point P is shown in Fig 3.2.

Fig. 3.2

A rock of mass 180 kg moves along the line joining the centres of the two stars, from star A towards star B.

(i) Using Fig. 3.2, state and explain the variation of the direction of the gravitational force experienced by the rock as it moves from $x = 0.1 \times 10^{12}$ m to $x = 1.2 \times 10^{12}$ m.

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.... [2]

(ii) At a point where $x = 0.1 \times 10^{12}$ m, the speed of the rock is v.

Use data from Fig. 3.2, calculate the minimum value of v such that the rock is able to reach the point where $x = 1.2 \times 10^{12}$ m.

speed = ... m s^{-1} [2]

[Total: 6]