2 **(a)** State the relationship between gravitational potential ϕ and gravitational field strength g.

....

.... [1]

(b) In a binary star system, star B of mass M and radius R and star A of mass $3M$ and radius $2R$ are separated at a distance D between their centres, as shown in Fig. 2.1.
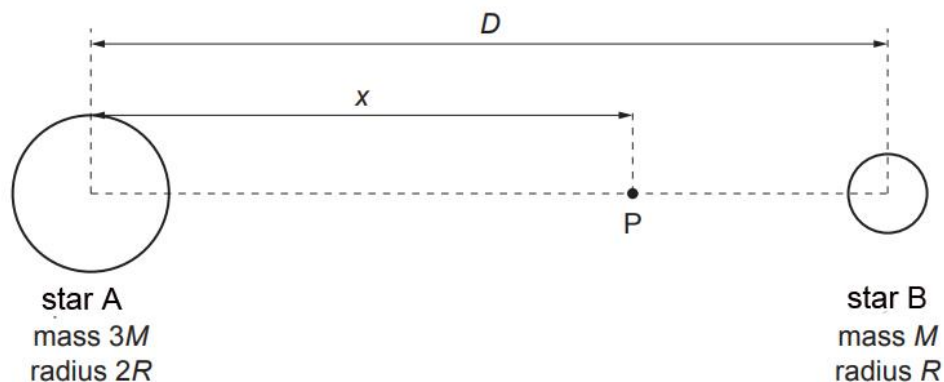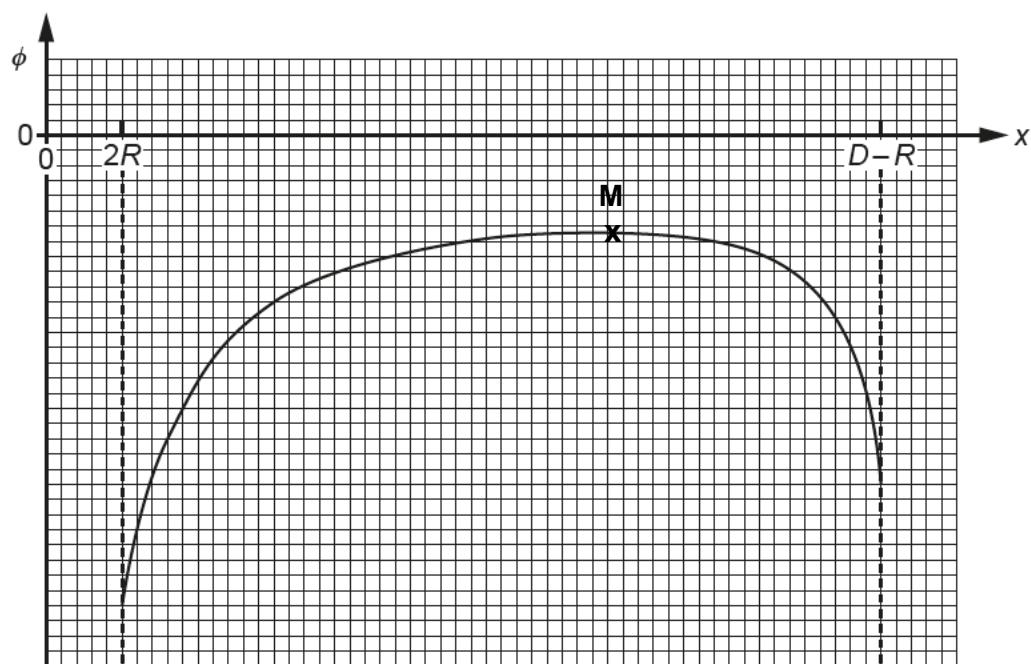

Fig. 2.1

Point P is a point along the line between the centres of the two stars, at a variable distance x from the centre star A.

The variation with x of the gravitational potential ϕ at point P, for points between the stars is shown in Fig. 2.2.

Fig. 2.2

(i) Deduce whether the gravitational field strength at the surface of star A is greater or less than the gravitational field strength at the surface of star B.
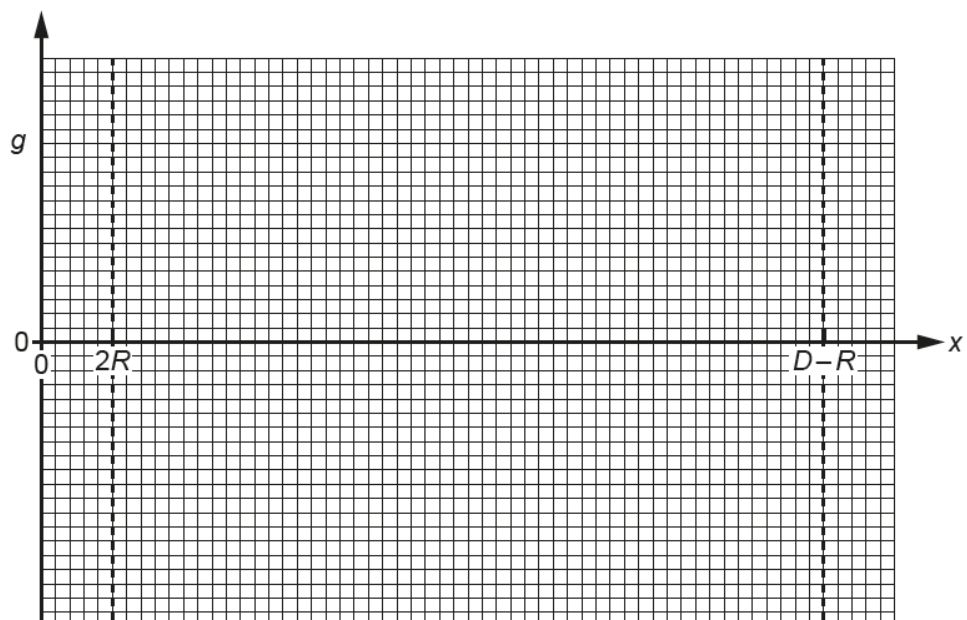
Show your workings, if any, in the spaces provided.

....

.... [2]

(ii) Explain the significance of the maximum point **M** on the graph.

....

....

.... [1]
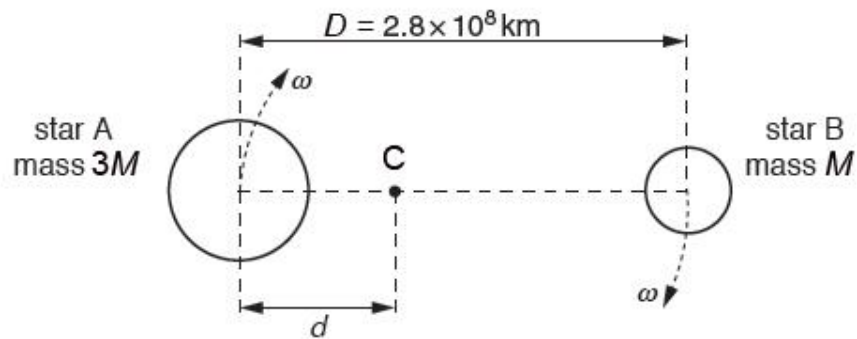
(iii) On Fig. 2.3, sketch the variation with x of the gravitational field strength g at point P between $x = 2R$ and $x = D - R$. No numerical values is required.

Fig. 2.3

[2]

(c)   The stars in **(b)** are in circular orbits with the same angular speed ω and with the centres of both orbits at point C, a distance d from the centre of star A, as shown in Fig. 2.4.

Fig. 2.4

(i)   Explain why the centripetal force acting on both stars has the same magnitude.

....

....

.... [1]

(ii)   Explain why both stars rotate with the same angular speed ω.

....

....

.... [1]

(ii)   The separation D of the centres of the stars is 2.8×10^8 km.
Determine the distance d.

d = ... km   [2]

[Total: 10]