Part 2 Gravitational fields

(a) State Newton's universal law of gravitation. *[3]*

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(b) Deduce that the gravitational field strength g at the surface of a spherical planet of uniform density is given by

$$g = \frac{GM}{R^2}$$

where M is the mass of the planet, R is its radius and G is the gravitational constant. You can assume that spherical objects of uniform density act as point masses. *[2]*

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(c) The gravitational field strength at the surface of Mars g_M is related to the gravitational field strength at the surface of the Earth g_E by

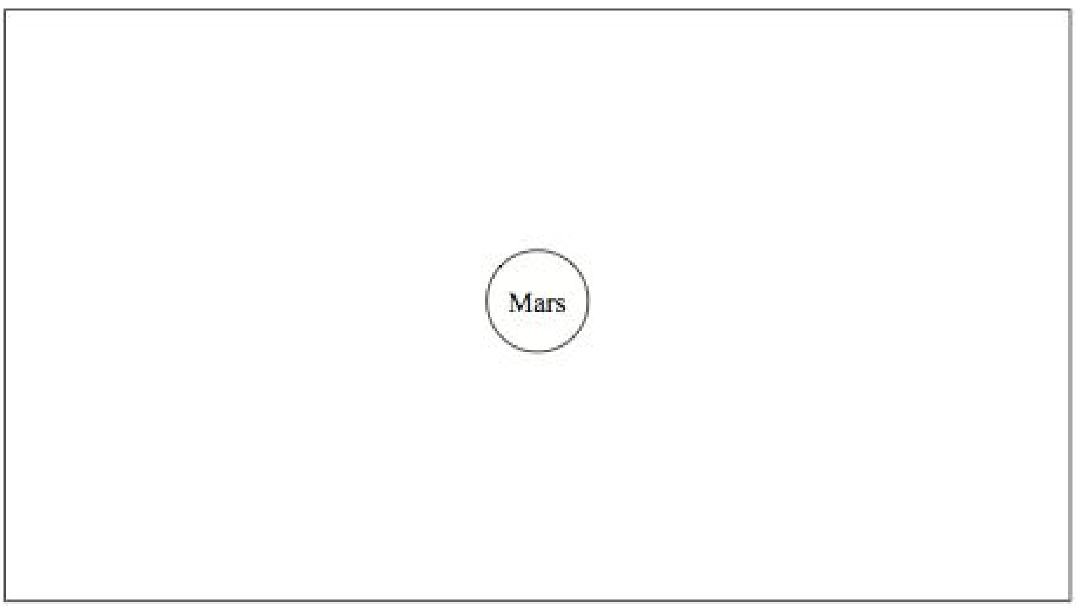
$$g_M = 0.38 \times g_E.$$

The radius of Mars R_M is related to the radius of the Earth R_E by

$$R_M = 0.53 \times R_E.$$

Determine the mass of Mars M_M in terms of the mass of the Earth M_E. [2]

(d) (i) On the diagram below, draw lines to represent the gravitational field around the planet Mars. [1]



Part 2 Gravitational fields

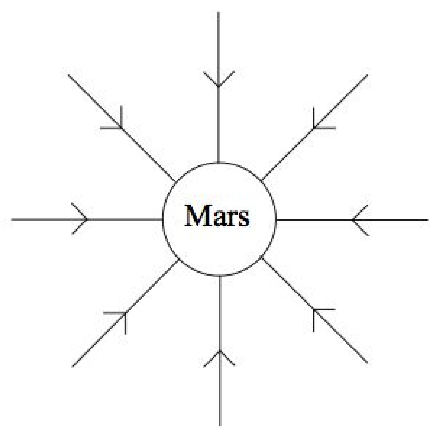
(a) there is an attractive force;
between any two point/small masses;
proportional to the product of their masses;
and inversely proportional to the square of their separation; ***[3 max]***
Accept formula with all terms defined.

(b) use of $g = \frac{F}{m}$ and $F = \frac{GmM}{R^2}$;
evidence of substitution/manipulation;
to get $g = \frac{GM}{R^2}$ ***[2]***

(c) $\frac{g_M}{g_E} = \frac{\frac{M_M}{R_M^2}}{\frac{M_E}{R_E^2}} \Rightarrow \frac{M_M}{M_E} = \frac{g_M}{g_E} \times \left[\frac{R_M}{R_E}\right]^2$;

$M_M (= 0.38 \times 0.53^2 M_E) = 0.11 M_E$; ***[2]***

(d) (i) radial field with arrows pointing inwards; ***[1]***



(ii) field between A and B is not equal to field at surface;
acceleration is not constant between these two points; ***[2]***