GRAVITATIONAL FIELDS AND ORBITS

Q1/ (i) $g_\oplus = GM_\oplus / R_\oplus^2 = \dfrac{6.67\times10^{-11} \times 5.972\times10^{24}}{(6371\times10^3)^2}$

$= \boxed{9.81 \text{ N/kg}}$

(ii) $g_M = 3.72 \text{ N/kg}$.

$N = g_M R_M^2 / G \quad \therefore \quad M = \dfrac{3.72 \times (3390\times10^3)^2}{6.67\times10^{-11}}$

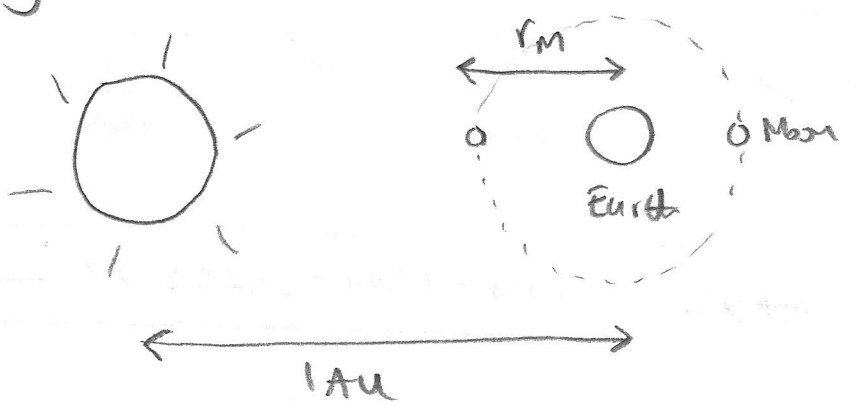
(mass of Mars)

$\boxed{M = 6.41\times10^{23} \text{ kg}}$

ie $0.107\, M_\oplus$

[Actually 6.39×10^{23} kg since $R = 3389.5$ km]

(iii)



$57.0 R_\oplus < r_M < 63.8 R_\oplus$

$1 \text{ AU} = 1.496\times10^{11} \text{ m}$.

For 1 kg of sea water is

(i) Due to the Sun:

$g_\odot = \dfrac{GM_\odot}{\text{AU}^2} = \dfrac{6.67\times10^{-11} \times 332937 \times 5.972\times10^{24}}{(1.496\times10^{11})^2}$

$= \boxed{5.92\times10^{-3} \text{ N/kg}}$ [0.06% of $g_\oplus$]

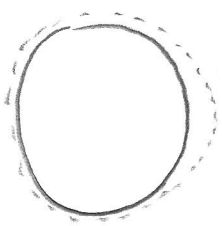
(ii) Due to the Moon:

$g_M = \dfrac{GM_M}{(57R_\oplus)^2} = \dfrac{6.67\times10^{-11} \times 7.35\times10^{22}}{(57\times6371\times10^3)^2} = \boxed{3.72\times10^{-5} \text{ N/kg}}$

↑ ie for max g_M $\quad \approx 90/159$

(if $r_M = 63.8\,R_\oplus$, $g_M = g_\oplus/200$; if $r_M = 60\,R_\oplus$ $g_M = g_\oplus/177$ ← which is what is stated in the NOAA tides educational website)

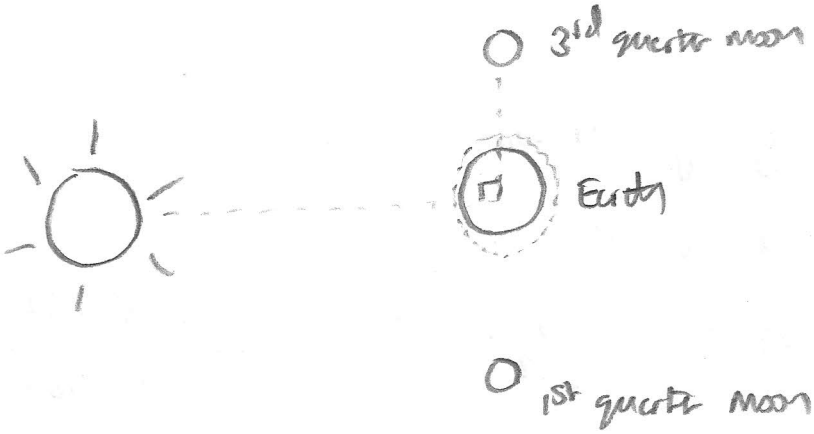
Tides are formed by the <u>difference</u>* in net gravitational force <u>across</u> the Earth, and hence cause a 'tidal bulge' in the (movable) mass of liquid water in the oceans.



When the Sun and moon act together they can enhance the tidal bulge → Spring tides.

SPRING: SUN – MOON – EARTH in a line

NEAP: SUN – MOON – EARTH are ⊥



* Since <u>across</u> the Earth, tidal forces go as $\frac{1}{r^3}$ (ie $\frac{d}{dr}\left(\frac{1}{r^2}\right)$) rather than $\frac{1}{r^2}$ as per gravitational fields.