Mechanics Classwork I: Answers

1. (i) $a = \frac{G M_{moon}}{r^2_{moon}} = \frac{6.67\times10^{-11} \times 7.36\times10^{22}}{(1.74\times10^{6})^2} = 1.62\ ms^{-2}$

(ii) $a = \frac{G M_{sun}}{r^2} = \frac{6.67\times10^{-11} \times 1.99\times10^{30}}{(10^{9})^2} = 132\ ms^{-2}$

---

2 [Weight is FORCE = mass × accel]

(i) 98.1 N

(ii) 16.2 N

(iii) 1.32×10^{3} N

---

3 Yes, it does mean that the gravitational force between 2 spheres is the same as that between 2 point masses.
Consider 2 masses: A (sphere) & B (point)

(A) $\overset{\cdot}{B}$ ⇨ $|\underline{F}_{A\,on\,B}| = \frac{G m_A m_B}{r^2}$

N3 → $|\underline{F}_{B\,on\,A}| = \frac{G m_A m_B}{r^2}$

But the force exerted by B would be the same if it was a sphere

(A) (B) ⇨ $|\underline{F}_{B\,on\,A}| = \frac{G m_A m_B}{r^2}$

i.e. the expression for the force between 2 point masses is also valid for 2 spheres

---

4 (i) $a_{pud} = 9.81\ ms^{-2}$

(ii) $|\underline{F}_{Earth\ on\ pud}| = 9.81 \times 1 = 9.81N$

$\therefore |\underline{F}_{pud\ on\ Earth}| = 9.81N$

$\therefore a_{Earth} = \dfrac{9.81}{5.98\times10^{24}} = 1.64\times10^{-24}\ ms^{-1}$

(iii) $t = \sqrt{\dfrac{2x}{a}} = \sqrt{\dfrac{2\times10^{-10}}{1.66\times10^{-24}}} = 1.10\times10^{7}s$ ($\sim 4\frac{1}{2}$ months)

---

5 

Centre of further sphere is distance $r+2a$ from BH

$\therefore$ accel due to gravity there $= \dfrac{GM}{(r+2a)^2}$

$$= \frac{GM}{r^2}\left(1+\frac{2a}{r}\right)^{-2} \simeq \frac{GM}{r^2}\left(1-\frac{4a}{r}\right) = g_r - \frac{4GMa}{r^3}$$

---

6. Force on nearer sphere $= mg_r$ — m: mass of one sphere

Force on further sphere $= mg_r - \dfrac{m4GMa}{r^3}$

Tidal force $= \Delta F = \dfrac{4GMma}{r^3}$

Water mol's pulled apart when:

$$r^3 = \frac{4\times6.67\times10^{-11}\times10^{10}\times1.99\times10^{30}\times3\times10^{-26}\times2\times10^{-10}}{10^{-11}} \rightarrow r = 147m$$
