2.1 (a) No. of atoms in one mole $= 6.022 \times 10^{23}$ ①

$1 \text{ yoctomole} = 10^{-24} \times 6.022 \times 10^{23}$

No. of atoms in 1 yoctomole = 0

(b) 1 century = 100 years $= 365 \times 24 \times 60 \times 60 \times 100$

$= 31.536 \times 10^{8}$ seconds

1 nanocentury $= 31.536 \times 10^{8} \times 10^{-9}$ seconds

= ~~0.031536~~ 3.1536 seconds

It is close to the value of $\pi \left(\frac{\text{circumference of circle}}{\text{diameter of circle}}\right)$

2.2. Average capacity of one CD = 700 MiB

= 700 Mebibyte

$= 700 \times 1048576$ bytes

$= 7.34 \times 10^{8}$ bytes

No. of CDs equivalento to 1 peta byte $= \dfrac{10^{15}}{7.34 \times 10^{8}}$

$= 1.36 \times 10^{6}$

Thickness of each CD = 1.2 mm

Height of a stack of 1.36×10^{6} CDs $= 1.2 \times 10^{-3} \text{ m} \times 1.36 \times 10^{6}$

$= 1.632 \times 10^{3}$ m

= <u>1632</u> m

2.3 Approximate no. of atoms in universe $= 10^{80}$

If each atom represents a bit,

10^{80} bits represent numbers upto $(2)^{10^{80}}$

$$x = (2)^{10^{80}}$$

$$\log_{10} x = \log_{10} (2)^{10^{80}}$$

$$= 10^{80} \log_{10}(2)$$

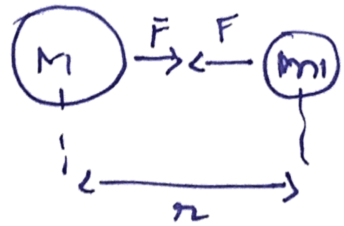
$$= 10^{80} \times 0.301$$

$$\log_{10} x = 3.01 \times 10^{79}$$

$$x = 10^{3.01 \times 10^{79}}$$

$$x = 10^{(3 \times 10^{79})}$$

2.4 Gravitational force between bodies of mass M and $m' = G \frac{M \times m'}{r^2}$, where r is the distance between masses.



Gravitational force on a mass m' at the surface of earth $= \dfrac{G \times 5.98 \times 10^{4} kg \times m'}{(6.378 \times 10^{6})^2}$

Gravitational force on a mass m' produced by 1kg at distance 1m $= \dfrac{G \times 1 kg \times m'}{1}$

2.4) $F \propto$ Accelaration

Ratio of accelaration $= \dfrac{G \times 5.98 \times 10^{4} \times m'}{(6.378 \times 10^{6})^{2}} \Big/ \dfrac{G \times 1\,kg \times m'}{1}$

$= \dfrac{5.98 \times 10^{4}}{(6.378 \times 10^{6})^{2}} = \dfrac{5.98 \times 10^{4}}{40.68 \times 10^{12}}$

$= 0.123 \times 10^{-8} = 1.23 \times 10^{-9}$

Ratio in decibels $= 20 \log_{10}(1.23 \times 10^{-9})$

$= 20 [\log_{10} 1.23 + \log_{10} 10^{-9}]$

$= 20 [0.0899 - 9]$

$\simeq 20 \times -9$

Ratio $\simeq \underline{-180\ dB}$

2.7 (a) To climb out of potential energy $-\frac{GMm}{r}$

kinetic energy > potential energy.

$$\frac{1}{2}mv^2 > \left|-\frac{GMm}{r}\right|, \text{ where } v = \text{escape velocity.}$$

$$\frac{1}{2}v^2 > \left|-\frac{GM}{r}\right|$$

$$v^2 > \frac{2GM}{r}, \quad v > \sqrt{\frac{2GM}{r}}.$$

(b) Nothing can be faster than light,

hence $v \leq c$, c is speed of light.

$$\sqrt{\frac{2GM}{r}} < v \leq c. \Rightarrow \sqrt{\frac{2GM}{r}} \leq c.$$

$$\frac{2GM}{r} \leq c^2, \quad r \geq \frac{2GM}{c^2}.$$

For radii $r < \frac{2GM}{c^2}$ nothing can escape the mass.

(c) Rest energy of mass $M = Mc^2$.

Energy of photon of wavelength $\lambda = \frac{hc}{\lambda}$

$$\frac{hc}{\lambda} = Mc^2, \quad \boxed{\lambda = \frac{h}{Mc}}$$

2.7 (d) Given $\lambda = \frac{2GM}{c^2}$ from 2.7 b.

$$\frac{2GM}{c^2} = \frac{h}{Mc} \quad \text{from } 2.7.c$$

$$M^2 = \frac{hc}{2G}, \quad M = \sqrt{\frac{hc}{2G}}.$$

(e) $$r = \frac{2GM}{c^2} = \frac{2G}{c^2}\sqrt{\frac{hc}{2G}}$$

$$= \frac{1}{c}\sqrt{\frac{h/c}{2G}}$$

(f) $$\text{Energy} = \left|\frac{-GMm}{r}\right| = \left[\frac{-GM.\sqrt{\frac{hc}{2G}}}{\frac{2G}{c^2}\sqrt{\frac{hc}{2G}}}\right]$$

$$= \frac{1}{2}Mc^2 = \frac{1}{2}\sqrt{\frac{hc}{2G}}\cdot c^2$$

(g) $E = h\nu$, $\nu = E/h$, period $= h/E$