Schutz 8.2 (a) From Newton, $G = 6.673 \times 10^{-11}\ m^3\ kg^{-1}\ s^{-2}$

$$\frac{G}{c^2} = \frac{6.673 \times 10^{-11}\ m^{\cancel{3}\,1}\ kg^{-1}\ \cancel{s^{-2}}}{9 \times 10^{16}\ \cancel{m^2}\ \cancel{s^{-2}}}$$

$$= \boxed{7.41 \times 10^{-28}\ m\ kg^{-1}}$$

$$\frac{c^5}{G} = \frac{3^5 \times 10^{40}\ m^5\ s^{-5}}{6.673 \times 10^{-11}\ m^3\ kg^{-1}\ s^{-2}}$$

$$= \frac{243}{6.673} \times 10^{51}\ m^2\ kg\ s^{-3}$$

$1\ J = m^2\ kg\ s^{-2}$

$$= \boxed{3.64 \times 10^{52}\ J\ s^{-1}}$$

Davidson [illegible]

5-9-2024.

Schutz 8.2 (b)

$\hbar$:

$$1\,\hbar = 1.055 \times 10^{-34}\ \mathrm{J\,s}$$

$$3.629 \times 10^{52}\ \mathrm{J} = 1\,\mathrm{s}.$$

$$1\,\mathrm{J} = 2.76 \times 10^{-53}\ \mathrm{s}$$

$$\Rightarrow 1\hbar = (1.055 \times 10^{-34}) \times (2.76 \times 10^{-53})\ \mathrm{s}^2$$

$$(1\,\mathrm{s} = 3 \times 10^{8}\ \mathrm{m})$$

$$\Rightarrow 1\hbar = 1.055 \times 2.76 \times 9 \times 10^{-34} \times 10^{-53} \times 10^{16}\ \mathrm{m}^2$$

$$= \boxed{2.62 \times 10^{-70}\ \mathrm{m}^2}$$

$m_e$:

$$7.425 \times 10^{-28}\ \mathrm{m} = 1\,\mathrm{kg}.$$

$$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$$

$$= 9.11 \times 10^{-31} \times 7.425 \times 10^{-28}\ \mathrm{m}$$

$$= \boxed{6.76 \times 10^{-58}\ \mathrm{m}}$$

$m_p$ :

$$m_p = 1.673 \times 10^{-27} \times 7.425 \times 10^{-28}\ m$$

$$= \boxed{1.24 \times 10^{-54}\ m}$$

$m_{\odot}$ :

$$m_{\odot} = 1.989 \times 10^{30} \times 7.425 \times 10^{-28}\ m$$

$$= \boxed{1.48 \times 10^{3}\ m}$$

$m_{\oplus}$ :

$$m_{\oplus} = 5.973 \times 10^{24} \times 7.425 \times 10^{-28}\ m$$

$$= \boxed{4.43 \times 10^{-3}\ m}$$

$L_{\odot}$ :

$$3.629 \times 10^{52}\ \frac{J}{s} = 1 \quad \Rightarrow \quad 1\ \frac{J}{s} = 2.76 \times 10^{-53}$$

$$L_{\odot} = 3.9 \times 10^{26}\ kg\ m^2 s^3$$

$$= 3.9 \times 10^{26}\ \frac{J}{s}$$

$$= 3.9 \times 10^{26} \times 2.76 \times 10^{-53}$$

$$= \boxed{1.07 \times 10^{-26}}$$

Schutz 8.2 (c)

(i) $\rho = 10^{17}\ kg\ m^{-3}$.

$7.425 \times 10^{-28}\ m\ kg^{-1} = 1$

$\Rightarrow 10^{-27}\ m\ kg^{-1} \simeq 1$

$\frac{kg}{m} \simeq 10^{27}$

$\Rightarrow 10^{17}\ kg\ m^{-3}$

$\simeq 10^{17}\ 10^{27}\ m^{-2}$

$= \boxed{10^{44}\ m^{-2}}$

(ii) $p = 10^{33}\ kg\ s^{-2}\ m^{-1}$

$= 10^{33}\ J\ m^{-3}$

$= 10^{33}\ J\ s^{-1}\ m^{-3}\ s.$

$J s^{-1} = 2.76 \times 10^{-53}$

$= 2.76 \times 10^{-20}\ m^{-3}\ s.$

$3 \times 10^{8}\ m = 1 s$

$= 2.76 \times 10^{-20}\ m^{-3} \times 3 \times 10^{8}\ m$

$= \boxed{8.28 \times 10^{-12}\ m^{-2}}$

(iii). $g = 9.8 \ m s^{-2}$

$1 s = 3 \times 10^8 m$, $s^{-2} = \frac{1}{9 \times 10^{16}} m^{-2}$

$g = \frac{9.8}{9} 10^{-16} \ m \ m^{-2}$

$= \boxed{1.08 \times 10^{-16} \ m^{-1}}$

(iv): $L = 10^{41} \ J s^{-1}$

$1 = 3.629 \times 10^{52} \ J s^{-1}$

$\Rightarrow \quad 1 J s^{-1} = 2.76 \times 10^{-53}$

$L = 10^{40} \times 2.76 \times 10^{-53}$

$= \boxed{2.76 \times 10^{-13}}$

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Schutz 8.2 (d).

planck length: $[G] = kg^{-1}\,\frac{m^3}{s^2}$, $[c] = \frac{m}{s}$, $[\hbar] = kg\,\frac{m^2}{s}$.

$$\Rightarrow \left[\frac{G\hbar}{c^3}\right] = m^2$$

$$\sqrt{\frac{G\hbar}{c^3}} = \text{planck length in SI},$$

$$= \boxed{1.616 \times 10^{-35}\ m} \Leftarrow \text{planck length.}$$

checked with calculator.

planck mass: $\left[\sqrt{\frac{\hbar c}{G}}\right] = kg.$

$$\sqrt{\frac{\hbar c}{G}} = \sqrt{\frac{1.055 \times 10^{-34} \times 3 \times 10^{8}}{6.67 \times 10^{-11}}}\ kg$$

$$= \sqrt{4.75 \times 10^{-16}}\ kg$$

$$= \boxed{2.18 \times 10^{-8}\ kg} \Leftarrow \text{planck mass}$$

planck time: we use planck length $= 1.616 \times 10^{-35}$ m

$$1m = \frac{1}{3} \times 10^{-8} s,$$

$$\text{planck length} = 1.616 \times 10^{-35} \times \frac{1}{3} \times 10^{-8} s$$

$$= \boxed{5.39 \times 10^{-44} \ s.}$$ ← planck time.

planck mass is much much larger than the mass of a particle, which is $\sim 10^{-31} \to 10^{-27}$ kg, like a lot larger.

planck time is also extremely tiny, making $\frac{1}{\text{planck time}}$ an extremely high frequency corresponding to particles of a lot of energy. Planck length implies the same thing in terms of wavelength.

Altogether, "planck" speaks high energy, much higher than that of a typical particle.

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