Arvind Borde: Phy 12 Homework 12

Keep in mind

For a "hatted" frame $(\hat{t}, \hat{x})$, moving with speed v relative to an unhatted frame (t, x), we have

$$\Delta t = \gamma \Delta \hat{t}$$

$$\Delta x = \Delta \hat{x} / \gamma$$

where

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$

If we set $\beta = v/c$, then this means that

$$\gamma = \frac{1}{\sqrt{1-\beta^2}} \quad \text{or} \quad \frac{1}{\gamma^2} = 1 - \beta^2 \quad \text{or} \quad \beta^2 = 1 - \frac{1}{\gamma^2}.$$

So

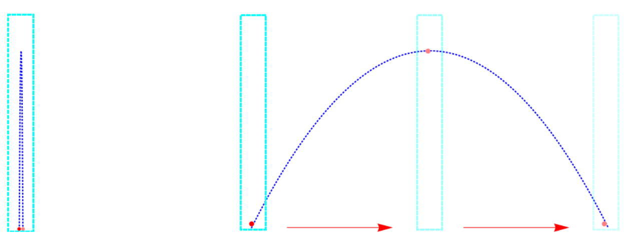
$$\beta = \frac{v}{c} = \sqrt{1 - \frac{1}{\gamma^2}}.$$

Questions

(1) Nope. Experience tells us this. The laws of mechanics support this ($F = ma$ is invariant). Einstein's principle of relativity makes this into an absolute principle.

(2) There is no "absolute" motion that allows you to tell whether you are "really" moving or not – only relative motion between two systems.

(3) Back in his hand.



(4) Equally valid.

(5) c.

(10) Yes, but in too small a way to measure. 90 km/hr= $9^10^4/3600 = 25$ m/s, and $\gamma(25\text{m/s}) = 1.0000000000000034$.

(11) As $c \to \infty$, $\gamma \to 1$, so there would be no relativistic effects.

(16) No, because $M \to \infty$ as $v \to c$.

Misconceptuals

(1) (a) 50 m.

(2) (c) Every 0.87 s.

(4) (b) The ship's captain.

(5) (f) Both (b) and (c).

(6) (c) c.

(10) (e)

(11) (d)

Problems

(1) $\gamma(.85c) = 1.90$.
$\ell = [\gamma(.85c)] \times 44.2 = 84.0\text{m}$.

(2) $\gamma(2.7 \times 10^8\text{m/s}) = 2.29$
$t = (4.76 \times 10^{-6})/[\gamma(2.7 \times 10^8\text{m/s})] = 2.08 \times 10^{-6}\text{s}$.

(3) $\gamma(2.9 \times 10^8\text{m/s}) = 3.91$
$t = 135/[\gamma(2.9 \times 10^8\text{m/s})] = 34.5\text{ly}$.

(4) $\gamma = 4.4 \times 10^{-8}/2.6 \times 10^{-8} = 1.69$
So,

$$\frac{v}{c} = \sqrt{1 - \frac{1}{1.69^2}} = 0.81$$

Therefore, $v = 0.81c = 2.4 \times 10^8\text{m/s}$.

(5) $\gamma = 49/35 = 1.4$.
So,

$$\frac{v}{c} = \sqrt{1 - \frac{1}{1.4^2}} = 0.70$$

Therefore, $v = 0.70c = 2.1 \times 10^8\text{m/s}$.

(6) $\gamma = 1/0.9 = 1.11$.
So,

$$\frac{v}{c} = \sqrt{1 - \frac{1}{1.11^2}} = 0.43$$

Therefore, $v = 0.43c = 1.3 \times 10^8\text{m/s}$.

(21) $E = mc^2 = (9.1 \times 10^{-31})(3 \times 10^8)^2 = 8.2 \times 10^{-14}\text{J}$.
In MeV, $E = (8.2 \times 10^{-14})/(1.6 \times 10^{-13}) = 0.511\text{MeV}$.

(22) $E = 200\,\text{MeV} = 200 \times (1.6 \times 10^{-13})\text{J} = 3.2 \times 10^{-11}\text{J}$.
So,

$$\begin{aligned} m = E/c^2 &= (3.2 \times 10^{-11})/(3 \times 10^8)^2 \\ &= (3.2 \times 10^{-11})/(9 \times 10^{16}) \\ &= 3.6 \times 10^{-28}\text{kg} \end{aligned}$$

(23) $m = E/c^2 = 10^{20}/(9 \times 10^{16}) = 1.1 \times 10^3$ kg.