

(Multiple choice questions are worth 12 points each.)

1. How fast would a spaceship have to travel so only one year of travel time (as measured aboard the spaceship) elapses as it goes to a distant star system in a trip that measured from earth takes five years?

- a. $5c$
- b. $c/5$
- c. $0.8c$
- d. $0.98c$**

$$\Delta t = \frac{\Delta t'}{\gamma}$$

$$\gamma = \frac{5}{1} = 5$$

$$\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = 5$$

$$1 - \frac{v^2}{c^2} = \frac{1}{25}$$

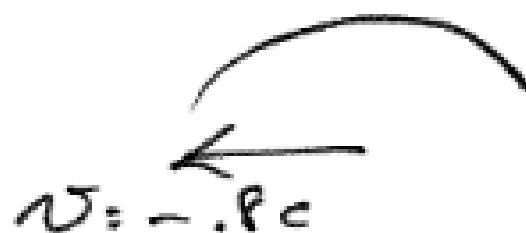
$$\frac{v^2}{c^2} = 1 - \frac{1}{25} = 0.96$$

$$v = \sqrt{0.96} c$$

$$\underline{v = 0.98c}$$

2. With respect to the earth, object 1 is moving at speed $0.80c$ to the right. Object 2 is moving in the same direction at a speed $0.80c$ with respect to object 1. How fast is object 2 moving with respect to earth?

- a. $0.64c$
- b. $0.80c$
- c. $0.98c$**
- d. $1.6c$



$$v = -.8c$$

$$u_x = .8c$$

$$u_x' = \frac{u_x - v}{1 - \frac{u_x v}{c^2}} = \frac{.8c - (-.8c)}{1 - \frac{(-.8c)(.8c)}{c^2}}$$

$$u_x' = \frac{1.6c}{1.64} = \underline{\underline{0.976c}}$$

3. At what speed would the density of a cubic object double?



- a. 0.71 c
- b. 0.82 c
- c. 0.87 c
- d. 2 c

$$\rho_0 = \frac{M_0}{V_0} = \frac{M_0}{l_0 l_0 l_0}$$

$$M = \gamma M_0$$

$$V = l_0 l_0 \frac{l_0}{\gamma}$$

$$\rho = \frac{M}{V} = \frac{\gamma M_0}{V_0/\gamma} = \gamma^2 \rho_0$$

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

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

$$\frac{v^2}{c^2} = \frac{1}{2}$$

$$v = \sqrt{0.5} c$$

$$\gamma^2 = 2$$

$$\gamma = \sqrt{2}$$

$$v = \underline{\underline{0.707c}}$$

4. If a nuclear reactor produces 1000 MW average power for 30 days, how much mass has been converted into energy?

- a. 3×10^{-7} kg
- b. 3×10^{-2} kg
- c. 3×10^2 kg
- d. 3×10^6 kg

$$\left(10^3 \times 10^6 \frac{\text{J}}{\text{s}} \right) 30 \text{ days } 3600 \frac{\text{s}}{\text{h}} 24 \frac{\text{h}}{\text{d}}$$

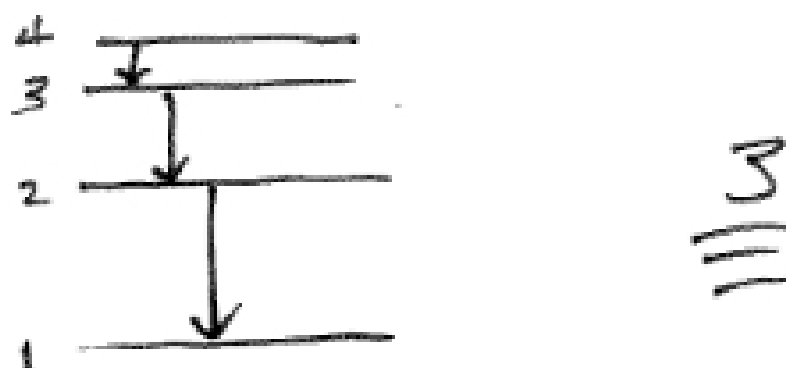
$$= 2.59 \times 10^{15} \text{ J}$$

$$\Delta E = \Delta M c^2$$

$$\Delta M = \frac{2.59 \times 10^{15} \text{ J}}{(3 \times 10^8)^2} = 2.88 \times 10^{-2} \text{ kg}$$

5. If the hydrogen atom is in the $n = 4$ state, what is the largest number of photons that can be emitted as the atom goes back to the ground state?

- a. 1
- b. 2
- c. 3**
- d. 4



6. What is the probability of finding a particle in the region from $x = 1$ to $x = 2$ if its wave function is $\Psi = 0.030 x^2$ in that region?

- a. 5.6×10^{-3}**
- b. 3.4×10^{-3}
- c. 6.0×10^{-2}
- d. 2

$$\begin{aligned}
 P &= \int_1^2 \Psi^* \Psi dx \\
 &= \int_1^2 (0.030 x^2)(0.030 x^2) dx \\
 &= (0.03)^2 \int_1^2 x^4 dx \\
 &= (0.03)^2 \left[\frac{x^5}{5} \right]_1^2 \\
 &= (0.03)^2 \left[\frac{2^5}{5} - \frac{1}{5} \right] \\
 &= (0.03)^2 \left[\frac{32}{5} - \frac{1}{5} \right] = 9 \times 10^{-4} \left(\frac{31}{5} \right) \\
 &= 5.58 \times 10^{-3}
 \end{aligned}$$