Oct 11

Pick up a whiteboard & marker for each group, and your clicker

Next semester: I will offer a second semester version of this class (numbered 0175). The times are TH 1:00-2:45, with recitation F 11:00-11:50.

Problem 5. P. 72 (page 218)

e^- in accelerator

$F = 1.6 \times 10^{-13}\,N$ for 2m in direction of motion

$|\vec{v}_f| = ?$

$\frac{|\vec{v}_i|}{c} = 0.95$

$\Delta E = W \Rightarrow E_f = E_i + W$

$= E_i + Fd$

$E_i = \gamma mc^2 = \frac{9.1 \times 10^{-31}\,kg\,(3 \times 10^8\,m/s)^2}{\sqrt{1 - .95^2}} = 2.62 \times 10^{-13}\,J$

$W = 1.6 \times 10^{-13}\,N \cdot 2m = 3.2 \times 10^{-13}\,J$

$E_f = 2.62 \times 10^{-13}\,J + 3.2 \times 10^{-13}\,J = 5.82 \times 10^{-13}\,J$

$E_f = \frac{mc^2}{\sqrt{1 - v_f^2/c^2}}$

$|\vec{v}_f| = 0.98c$

$$\gamma = \left(1-\left[\frac{|\vec{v}|}{c}\right]^2\right)^{-\frac{1}{2}} = 1+\frac{\left(-\frac{1}{2}\right)}{1}\left(-\left[\frac{|\vec{v}|}{c}\right]^2\right)+\frac{\left(-\frac{1}{2}\right)\left(-\frac{1}{2}-1\right)}{2\times 1}\left(-\left[\frac{|\vec{v}|}{c}\right]^2\right)^2+\frac{\left(-\frac{1}{2}\right)\left(-\frac{1}{2}-1\right)\left(-\frac{1}{2}-2\right)}{3\times 2\times 1}\left(-\left[\frac{|\vec{v}|}{c}\right]^2\right)^3+\cdots$$

$$\approx 1+\frac{1}{2}\left[\frac{|\vec{v}|}{c}\right]^2+\frac{3}{8}\left[\frac{|\vec{v}|}{c}\right]^4+\frac{5}{16}\left[\frac{|\vec{v}|}{c}\right]^6+\ldots$$

$$\approx 1+\frac{1}{2}\left[\frac{|\vec{v}|}{c}\right]^2 \approx \gamma \text{ for } |\vec{v}| \ll c \qquad \text{for } |\vec{v}| \ll c$$

$$E = \frac{mc^2}{\sqrt{1-\left(\frac{|\vec{v}|}{c}\right)^2}} = \left(1-\left[\frac{|\vec{v}|}{c}\right]^2\right)^{-\frac{1}{2}} mc^2 \approx \left(1+\frac{1}{2}\left[\frac{|\vec{v}|}{c}\right]^2\right)mc^2 = mc^2+\frac{1}{2}m|\vec{v}|^2$$

$E_{rest} + K$

Calculate $\gamma - 1$ for …

$\frac{v}{c} = 0.01$

first with $\frac{1}{\sqrt{1-v^2/c^2}}$, then $1+\frac{1}{2}\left(\frac{v}{c}\right)^2$

$\frac{1}{\sqrt{1-v^2/c^2}} - 1 = 5.0004e{-}5$

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

Now try with $v/c = 0.999$

$\gamma = 22.4$ true formula

True: $\gamma - 1 = 21.4$

Approx: $\gamma - 1 = \frac{1}{2}\frac{v^2}{c^2} = 0.499$

Now $v/c = 10^{-7}$

$\frac{1}{2}\left(\frac{v}{c}\right)^2 = 5e{-}15$

$\frac{1}{\sqrt{\ldots}} - 1 = 0$

Clicker questions

Q6: A ball whose mass is 2 kg travels at a velocity of < 0, –3, 4> m/s. What is the kinetic energy of the ball?	A) < 0, –6, 8 > J B) < 0, –3, 4 > J C) 2 J D) 10 J E) 25 J

not vector

$v^2 = 25\ m^2/s^2$

$\frac{1}{2}mv^2 = K$

Q7: A ball whose mass is 2 kg travels at a velocity of < 0, –3, 4> m/s. What is the rest energy of the ball?	A) 0 J B) 25 J C) 6e8 J D) 9e16 J E) 1.8e17 J

$Mc^2 = 2 \times (3\times10^8)^2$

$mc^2 = (9 \times 10^{-31})(3 \times 10^8)^2$

Q8: Consider an electron (mass 9e-31 kg) moving with speed v = 0.9c. What is its rest energy?	A) 7.3e-31 J B) 8.1e-14 J C) 1.05e-13 J D) 1.86e-13 J E) 2.7e8 m/s

Q9: Consider an electron (mass 9e-31 kg) moving with speed v = 0.9c. What is its total (particle) energy?	A) 7.3e-31 J B) 8.1e-14 J C) 1.05e-13 J D) 1.86e-13 J E) 2.7e8 m/s

Q10: Consider an electron (mass 9e-31 kg) moving with speed v = 0.9c. Its rest energy is 0.8e-13 J, and its (total) particle energy is 1.86e-13 J. What is its kinetic energy?	A) 7.3e-31 J B) 3.28e-14 J C) 8.1e-14 J D) 1.06e-13 J E) 1.86e-13 J

$E_{tot} = E_{rest} + K$

$K = E_{tot} - E_{rest}$

$=$ — —