Name___________________________________
Physics 120 Quiz 5, May 20, 2011

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

1. An electron is traveling at a speed of $v_{ie} = 0.99c$ when it encounters a region where there is a constant electric force directed opposite to its momentum. After traveling a distance d in this region, the electrons speed was observed to decrease to $v_{fe} = 0.93c$. How much work was done by the electric force slowing the electron down?

   a. $W = (\gamma_f - \gamma_i)m_e c^2$

   b. $W = \frac{1}{2}m_e(v_{fe}^2 - v_{ie}^2) - 2m_e c^2$

   c. $W = (\gamma_f - \gamma_i - 2)m_e c^2$

   d. $W = \frac{1}{2}m_e(v_{fe}^2 - v_{ie}^2)$

2a. Sodium-24 is radioactive and when it decays there is an emission of a beta particle (a high speed electron) and the sodium nucleus *transmutates* to a magnesium nucleus. The decay sequence for the beta decay of sodium is given as ${}^{24}_{11}Na \rightarrow {}^{0}_{-1}e + {}^{24}_{12}Mg$. Applying the energy and momentum principles, what is the speed of the beta particle if the ${}^{24}Na$ is at rest when the beta particle is emitted? (Hints: Assume that the beta particle and the magnesium nucleus move at non-relativistic speeds and take the rest mass of ${}^{24}Na$ to be $23.98492u$, the electron $5.49x10^{-4}u$, and ${}^{24}Mg$ 23.97845 and where an atomic mass unit, $1u = 1.66x10^{-27}kg$.)

2b. What is the speed of the recoiling ${}^{24}Mg$?

Useful formulas:

$\vec{p} = \gamma m\vec{v}$

$k_{eff,parallel} = n_{parallel}k_{individual}$

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

$k_{eff,series} = \frac{k_{individual}}{n_{series}}$

$\vec{v}_{avg} = \frac{\vec{v}_i + \vec{v}_f}{2}$

$stress = Ystrain \rightarrow \frac{F}{A} = Y\frac{\Delta L}{L}$

$\vec{F}_g = m\vec{g}$

$\vec{F}_{gravity} = \frac{GM_1M_2}{r_{12}^2}\hat{r}_{12}$

$\vec{F}_{spring} = -k\vec{s}; \quad \vec{s} = (L - L_o)\hat{s}$

$W = \int \vec{F}\cdot d\vec{r} = \Delta KE = -\Delta U$

$U_g = -\frac{GM_1M_2}{r}$

$U_g = mgy$

$U_s = \frac{1}{2}ks^2$

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

$KE = (\gamma - 1)mc^2$

Momentum Principle:

$$\vec{p}_f = \vec{p}_i + \vec{F}_{net}\Delta t; \quad \Delta t = \text{large}$$

$$\vec{p}_f = \vec{p}_i + \vec{F}_{net}dt; \quad dt = \frac{\Delta t}{n} = \text{small}$$

Position-update:

$$\vec{r}_f = \vec{r}_i + \vec{v}_{avg}\Delta t = \vec{r}_i + \frac{\vec{p}}{m\sqrt{1+\frac{p^2}{m^2c^2}}}\Delta t; \quad \Delta t = \text{large}$$

$$\vec{r}_f = \vec{r}_i + \vec{v}_f dt; \quad dt = \frac{\Delta t}{n} = \text{small}$$

$$\Delta E = W = \Delta U_g + \Delta U_s + \Delta KE$$

Energy principle:

Geometry /Algebra

Circles	*Triangles*	*Spheres*
$C = 2\pi r$	$A = \frac{1}{2}bh$	$A = 4\pi r^2$
$A = \pi r^2$		$V = \frac{4}{3}\pi r^3$

Quadratic equation: $ax^2 + bx + c = 0,$

whose solutions are given by: $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Vectors

magnitude of a vector: $|\vec{a}| = \sqrt{a_x^2 + a_y^2 + a_z^2}$

writing a vector: $\vec{a} = \langle a_x, a_y, a_z\rangle = |\vec{a}|\hat{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$

Useful Constants

$g = 9.8\,\frac{m}{s^2}$

$G = 6.67\times10^{-11}\,\frac{Nm^2}{kg^2}$

$1e = 1.6\times10^{-19}C$

$k = \frac{1}{4\pi\varepsilon_o} = 9\times10^9\,\frac{C^2}{Nm^2}$

$\varepsilon_o = 8.85\times10^{-12}\,\frac{Nm^2}{C^2}$

$1eV = 1.6\times10^{-19}J$

$\mu_o = 4\pi\times10^{-7}\,\frac{Tm}{A}$

$c = 3\times10^8\,\frac{m}{s}$

$h = 6.63\times10^{-34}Js$

$m_e = 9.11\times10^{-31}kg = \frac{0.511MeV}{c^2}$

$m_p = 1.67\times10^{-27}kg = \frac{937.1MeV}{c^2}$

$m_n = 1.69\times10^{-27}kg = \frac{948.3MeV}{c^2}$

$1amu = 1.66\times10^{-27}kg = \frac{931.5MeV}{c^2}$

$N_A = 6.02\times10^{23}$

$Ax^2 + Bx + C = 0 \rightarrow x = \frac{-B\pm\sqrt{B^2-4AC}}{2A}$