X1.2 309

PHYS-309(2) (Kaldon-21722) **Name** ____________________
WMU - Winter 2000
Exam 1 - 100,000 points **Book Title** ____________________

2/1/2000•Rev.2

State Any Assumptions You Need To Make – Show All Work – Circle Any Final Answers
Use Your Time Wisely – Work on What You Can – Be Sure to Write Down Equations
Feel Free to Ask Any Questions

For all problems, use $c = 2.998 \times 10^8$ *m/s.*

"Prime Minister Gryphbjulk! Captain Brylzhnic is coming!" **(50,000 points)**

1.) Above the planet Gamma, a great space battle is about to take place. When it "jumps" into the Gamman star system, the Alphan warship *Verisimilitude* is 155 million kilometers (1.55×10^{11} m) from Gamma. (a) How long does it take light to travel from the ship's entry point to the planet? *Express the answer in seconds and then in minutes.*

(b) The *Verisimilitude* approaches Gamma at 97.0% the speed of light. How long does it take the ship to travel from the entry point to the planet? *The Gammans don't know the ship is coming until the light information in part (a) reaches them – the difference between (a) and (b) is how much warning they have before the ship arrives.*

(c) The light that you see when you can see the approaching starship is reflected light from the Gamman sun. If the brightest color of light is $\lambda = 550$ *nm* (yellow light), how is this going to be shifted? Red shift or blue shift? Find the wavelength of the reflected light from the approaching starship as seen on Gamma.

$$\beta = \frac{\pm\lambda_{source} \mp \lambda_{obs}}{\lambda_{source} + \lambda_{obs}}$$

For a constant force, F, differentiating the relativistic momentum with respect to time gives us:

$$F = \frac{dp}{dt} = m\left(1 - \frac{v^2}{c^2}\right)^{-\frac{3}{2}} \frac{dv}{dt}$$ [*Serway M&M* Problem 1.28]. Integrating $F\,dt$ and $m\gamma^3\,dv$ or…

$$\int_0^t F dt = \int_0^v m\left(1 - \frac{v^2}{c^2}\right)^{-\frac{3}{2}} dv$$ gives us an equation for the relativistic v as a function of t: $$v = \frac{Fct}{\sqrt{(m^2c^2 + F^2t^2)}}$$

[This answer is consistent with the results of Problem 1.29c].

(d) Suppose that instead of coming in at a constant speed, that the *Verisimilitude* ($m = 160.0 \times 10^6$ kg) is going to apply a constant force and come to a stop at planet Gamma. Find the force needed to bring the starship to a stop in the same time as in (b). *If you didn't get an answer to (b), use* $t = 30.0$ *minutes. Note: F appears in* <u>*two*</u> *places in our equation.*

(e) Do the same calculation as in (d), but *classically*, using our old friendly equations from PHYS-205.

$1\ u = 1.66 \times 10^{-27}$ kg and converts to 931.5 MeV = $(931.5 \times 10^{6}) \times (1.609 \times 10^{-19}$ J) = 1.499×10^{-10} J of energy.

"*The Millennium is the Dawning of the Age of Aquarius…*" (50,000 points)

2.) Suppose there are particles called *millenniums*. Each millennium has a mass of 1.75 u. They are heading toward each other, each moving at $\gamma = 1000.$ in the lab frame. (a) How fast is either millennium going?

(b) Find the total relativistic momentum of these two millenniums.

(c) Find the total relativistic kinetic energy of the two millenniums.

(d) The two millenniums collide and stick together. Find the relativistic K.E. of the stuck-together millenniums.

(e) In the laboratory, two stuck-together millenniums have a mass of 3.33 u. Find the binding energy (B.E.) for the reaction M + M Ž MM. If this energy was released as a single photon, what would be its wavelength?

A Blank Worksheet for your convenience…