

**PHYSICS 4D**  
**SAMPLE EXAM 1**

Partial credit will be given so do what you can and make sure you show all work. **NO CREDIT WILL BE GIVEN IF NO WORK IS SHOWN!**

1. Two spaceships, each 100m long when measured at rest, travel toward each other with speeds of  $0.85c$  relative to earth. (12 pts)
  - a) How long is each ship as measured by someone on earth?
  - b) How fast is each ship traveling as measured by an observer on the other ship?
  - c) How long is each ship as measured by an observer on the other ship?
  - d) If an earth observer measures with his clock that it takes 85 min for the ships to pass each other, how long will an observer in one of the ships measure for the ships to pass each other?
2. An object having mass of 90 kg and traveling at a speed of  $0.850c$  collides with a stationary object having mass 1400 kg. The two objects stick together. (8pts)
  - a) Find the speed of the composite object.
  - b) Find the mass of the composite object
3. An electron is accelerated through a potential of 35 KeV. (10 pts)
  - a) Calculate the minimum wavelength of the resulting X-ray.
  - b) Explain how this minimum wavelength X-ray was produced.
4. a) Show that the dispersion relation for free relativistic electron waves is given by:  
$$\omega(k) = \sqrt{c^2 k^2 + (m_e c^2 / \hbar)^2} \quad (5 \text{ pts})$$
  - b) Find the phase velocity.
  - c) Show that the particle velocity is equal to the group velocity. (5 pts)
5. Referring to the electron diffraction experiment shown below: (10 pts)

**FIGURE 5.31 ON TEXTBOOK**

- a. Explain how this experiment shows the wave-particle duality of the electron.
  - b. Can you conclude that the electrons either passed through slit 1 or slit 2 to produce the interference pattern? Explain your answer by considering the interference pattern that is obtained by blocking each slit equal amounts of time and collecting data by having the other slit open.
  - c. Can it be possible that a particle can be at two different places at the same time???
6. Explain the significance of the Davisson-Germer Experiment. What did this experiment prove or disprove?