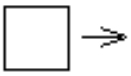
PHYSICS 2220 - PRACTICE EXAM #5

1. Cathy travels to a distant star in her starship while couch-potato Don stays on Earth. As the ship travels, Cathy measures the ship's length as 120 m and Don measures the ship's length as 90 m. If Don ages 5 years during Cathy's trip to the star, how much does Cathy age?

2. Amy travels to Sirius and back in a starship with a constant speed of 0.8 c while her twin brother Brent remains on Earth. Upon her return, Amy finds that she is 8.6 years younger than Brent. What is the distance to Sirius (in light years) as measured by Brent and by Amy?

3. A flag 5 m long and 3 m high is painted on the side of a spaceship. As the ship passes Earth, an Earth observer measures that the flag is square. If the ship's pilot measures 0.015 seconds between her heart beats, how much time does the Earth observer measure between her heart beats?

4. Each side of a square picture frame at rest measures 20 cm. As the frame flies past with a speed of 0.8 c, how long is the diagonal of the square frame?



5. A fast-moving particle has a total relativistic energy of 2790 MeV and a momentum given by pc = 2630 MeV. (pc is the momentum times the speed of light.) Find the rest energy of the particle and its speed.

6. A distant galaxy moves away from Earth at a speed of 0.8 c. A blob of gas is ejected from the galaxy by a huge explosion, and astronomers on Earth measure that the blob of gas is approaching Earth at 0.69 c. What is the speed of the gas blob as measured by someone in the distant galaxy?

7. An observer on a space station watches two spaceships leave in opposite directions, each with a speed of v = 0.6 c. How fast does each spaceship see the other spaceship moving?

8. What is the rest energy of 1 liter of water? (1 liter = 0.001 m^3 and the density of water is 1000 kg/m^3.)

9. At what speed is a particle's kinetic energy equal to twice its rest energy?

10. When light of wavelength 248 nm shines on a metal surface, electrons are ejected with a maximum kinetic energy of 1.0 eV. What is the cutoff wavelength of this metal?

11. How slowly must a 75 kg man walk so his wavelength is 1 m? How many years would he spend walking through a door in a wall that is 15 cm thick?

12. If an electron microscope is to "see" a small object, the electron's wavelength be at least as small as the object. How fast must an electron move to "see" an atom of diameter 0.1 nm?

13. Electrons are accelerated from rest through a potential difference of 6 V. What is the wavelength of the electrons?

14. The electrons described in the previous problem pass through two narrow slits separated by 0.25 mm. What is the distance between the central maximum and the 3rd order minimum on a screen 700 m away?

15. Estimate the minimum velocity of a nitrogen molecule N_2 of mass 4.65×10^{-26} kg inside a balloon of diameter 12 cm.

16. An alpha-particle of mass 6.65×10^{-27} kg passes horizontally through a slit 10^{-6} m wide. What is the minimum vertical velocity of the alpha-particle after going through the slit?

17. An air rifle is used to shoot a 1.2 g pellet moving horizontally at 150 m/s horizontally through a hole of diameter 2 mm. Estimate the minimum vertical velocity of the pellet after passing through the hole. (Ignore the force of gravity.)

18. An electron is in a one-dimensional box with sides $5a_o$ apart. What is the energy of the n = 3 energy level? What are the energy and wavelength of the photon emitted when the electron drops from the n = 3 to the n = 2 energy level? (a_o = Bohr radius = 0.0529 nm.)

19. Calculate the energies and wavelengths of all possible photons that can be emitted when an electron cascades from the n = 3 to the n = 1 orbit of the hydrogen atom.

20. The mass of a tritium atom (hydrogen with 2 neutrons) is 3.016049 u. What is the binding energy per nucleon? (m_H = 1.007825 u and m_n = 1.008665 u.)

21. A sample of carbon-11 atoms has an activity of 4×10^7 Bq. An hour later, the activity is 5.21×10^6 Bq. Find the half-life of carbon-11, and how many atoms there were initially.

22. Find the energy released in the alpha decay of Th-232 (atomic mass 232.038054 u) to Ra-228 (atomic mass 228.031069 u). The atomic mass of helium-4 is 4.002603 u.

23. In a nuclear fission reaction, a uranium-235 nucleus (235.043923 u) absorbs a neutron. The nucleus splits into a barium-141 nucleus (140.914406 u) and a krypton-92 nucleus (91.926153 u), releasing a number of neutrons in the process. Find the number of neutrons released, and the energy released.

24. In a nuclear fusion reaction, a lithium-7 nucleus (7.016003 u) combines with a hydrogen nucleus to form two helium-4 nuclei. Find the energy released.

Answers: (1) 3.75 yrs (2) 8.60 ly; 5.16 ly (3) 0.025 s (4) 23.3 cm
(5) 930 MeV, 0.943 c (6) 0.960 c (7) 0.882 c (8) 9×10^{16} J
(9) v = 0.943 c (10) 310 nm (11) 8.84×10^{-36} m/s, 5.37×10^{26} yrs
(12) 7.28×10^6 m/s (13) 5.01×10^{-10} m (14) 3.51 mm
(15) 1.89×10^{-8} m/s (16) 1.58 cm/s (17) 4.37×10^{-29} m/s
(18) 48.5 eV, 26.9 eV, 46.0 nm
(19) 12.1 eV, 103 nm; 10.2 eV, 122 nm; 1.89 eV, 656 nm (20) 2.83 MeV
(21) 20.4 min, 7.06×10^{10} atoms (22) 4.08 MeV (23) 3 neutrons, 173 MeV
(24) 17.35 MeV