PHYS 2411 Practice Exam # 3  Due on 21 October 2013 Name

(Work these problems from Chapter 8 so that you can master at least three (3) for the Examination #3).

18. A ball with a mass of 0.600 kg is initially at rest. It is struck by a second ball having a mass of 0.400 kg, initially moving with a velocity of toward the right along the x axis. After the collision, the 0.400 kg ball has a velocity of 0.250 m/s at an angle of $36.9^\circ$ above the x axis in the first quadrant. Both balls move on a frictionless, horizontal surface. (a) What are the magnitude and direction of the velocity of 0.200 m/s the 0.600 kg ball after the collision? (b) What is the change in the total kinetic energy of the two balls as a result of the collision?

28. Bird defense. To protect their young in the nest, peregrine falcons will fly into birds of prey (such as ravens) at high speed. In one such episode, a 600 gram falcon flying at 20.0 m/s ran into a 1.5 kg raven flying at 9.0 m/s. The falcon hit the raven at right angles to its original path and bounced back with a speed of 5.0 m/s. (These figures were estimated by one of the authors (WRA) as he watched this attack occur in northern New Mexico.) By what angle did the falcon change the raven’s direction of motion?

39. The mass of a regulation tennis ball is 57 g (although it can vary slightly), and tests have shown that the ball is in contact with the tennis racket for 30 ms. (This number can also vary, depending on the racket and swing.) We shall assume a 30.0 ms contact time throughout this problem. The fastest-known served tennis ball was served by “Big Bill” Tilden in 1931, and its speed was measured to be 73.14 m/s. (a) What impulse and what force did Big Bill exert on the tennis ball in his record serve? (b) If Big Bill’s opponent returned his serve with a speed of 55 m/s what force and what impulse did he exert on the ball, assuming only horizontal motion?

43. Experimental tests have shown that bone will rupture if it is subjected to a force density of $1.0 \times 10^8$ N/m$^2$. Suppose a 70.0 kg person carelessly roller-skates into an overhead metal beam that hits his forehead and completely stops his forward motion. If the area of contact with the person’s forehead is 1.5 cm$^2$, what is the greatest speed with which he can hit the wall without breaking any bone if his head is in contact with the beam for 10.0 ms?

56. In outer space, where gravity is negligible, a 75,000 kg rocket (including 50,000 kg of fuel) expels this fuel at a steady rate of 135 kg/s with a speed of 1200 m/s relative to the rocket. (a) Find the thrust of the rocket. (b) What are the initial acceleration and the maximum acceleration of the rocket? (c) After the fuel runs out, what happens to this rocket’s acceleration? Does it (i) remain the same as it was just as the fuel ran out, (ii) suddenly become zero, or (iii) gradually drop to zero? Explain your reasoning. (d) After the fuel runs out, what happens to the rocket’s speed? Does it (i) remain the same as it was just as the fuel ran out, (ii) suddenly become zero, or (iii) gradually drop to zero? Explain your reasoning.

57. A 70-kg astronaut floating in space in a 110-kg MMU (manned maneuvering unit) experiences an acceleration of 0.029 m/s$^2$ when he fires one of the MMU’s thrusters. (a) If the speed of 490 m/s the escaping gas relative to the astronaut is how much gas is used by the thruster in 5.0 s? (b) What is the thrust of the thruster?
70. Squids and octopuses propel themselves by expelling water. They do this by taking the water into a
cavity and then suddenly contracting the cavity, forcing the water to shoot out of an opening. A 6.50
kg squid (including the water in its cavity) that is at rest suddenly sees a dangerous predator. (a) If
this squid has 1.75 kg of water in its cavity, at what speed must it expel the water to suddenly
achieve a speed of 2.50 m/s to escape the predator? Neglect any drag effects of the surrounding
water. (b) How much kinetic energy does the squid create for this escape maneuver?

72. Astronomers believe that our moon originated when a Mars-sized body collided with the earth over
4.5 billion years ago, knocking off matter that condensed to form the moon. To get some idea of
how such a collision would affect the earth, assume that the collision occurred head-on (with the
two bodies traveling in opposite directions), that the Mars-sized body merged completely with the
earth and was originally the same mass as Mars, and that the earth’s orbital speed was the same as
it is now. Assume further that the speed of the colliding body was equal to the earth’s escape
velocity of 11 km/s (although it could have been greater). (a) By how much (in did such a collision
change the earth’s speed? Consult Appendix E. (b) How much thermal energy would such a collision
create? (c) To how many mega ton bombs is the energy in part (b) equivalent? (One ton of TNT
releases 4.184 X 10^9 J of energy.)

81. Beta decay is a radioactive decay in which a neutron in the nucleus of an atom breaks apart (decays)
to form a proton, an electron, and an antineutrino. The electron is also known as a beta particle. The
proton remains in the nucleus, while the electron and antineutrino shoot out. Before the existence
of the antineutrino was suspected, it was assumed that only the electron was emitted. Assuming
incorrectly) that there is no antineutrino, and that the neutron is initially at rest inside the nucleus,
find (a) the ratio of the speed of the electron to the speed of the proton just after the decay and (b)
the ratio of the kinetic energy of the electron to that of the proton just after the decay. Look up the
necessary masses in Appendix E. (c) Use the results from parts (a) and (b) to explain why it is the
electron, and not the proton, that shoots out of the nucleus. (Note: Electrons actually emerge with a
range of speeds; this observation provided the first experimental evidence that an additional
particle (the antineutrino) must also be emitted.)

81. Hints: (a) $P_{i,x} = P_{f,x}$ gives $0 = m_e v_e + m_p (-mv_p)$, $v_e = \frac{m_e}{m_p} = 1837. (b) \frac{K_e}{K_p} = \frac{1}{2} \frac{mv_e^2}{2mv_p^2} = ?$