ECE Physics 121 Exit Exam   Fall 2007

There are thirteen problems. The instructor will choose ten of the thirteen for the students. Of these ten problems the instructor can replace two of these with two of the instructor's choosing, should the instructor choose to do so. The student then does eight of the final ten problems, but must write down upon handing in the exam which of the problems the student is leaving out.

IMPORTANT:

(1) Keep Xerox copies of each GRADED exam
(2) The student's name and the grade must be plainly visible.
(3) Should your school be one of the four randomly chosen test sites, you will be asked to send Xeroxed, graded exams for me to grade check.

There are many philosophies as to how many formulae the students need to recall for exams. My personal preference is to insist on the memorization of a few expressions I (rather arbitrarily) deem fundamental. The students are given "less fundamental" expressions, and all necessary constants. We leave it up to the instructor to decide how he or she will deal with this issue.

1. A 2 kg ball falls into a box of sand from a height of 10 m. The ball comes to rest 3 cm below the surface of the sand. How large an average force was exerted on the ball by the sand?
2. To make a bounce pass a basketball player throws a 0.6 kg basketball toward the floor. The ball hits the floor with a speed of 5.4 m/sec at an angle of 65 degrees to the vertical. If the ball rebounds with the same speed and angle, what was the impulse delivered by the floor?
3. A person's lungs might hold 6.0 L of air at body temperature of 310 K and atmospheric pressure (101 kilopascals). Given that 21% of the molecules of air are oxygen, find the number of oxygen molecules in the lungs. Boltzmann's constant is 1.38 x 10^{-23} J/K.
4. Given a pendulum consisting of a mass M on the end of a string of length L, find an expression for the period of the pendulum in terms of given quantities and g, assuming small angles of displacement from the vertical.
5. The king's crown has a mass of 1.3 kg. However, when it is weighed while it is immersed in water its apparent weight is 11.17 newtons. The density of gold is 19.3 kg. m^3 . Is the crown pure gold? Prove your answer.
6. A football game begins with a kickoff in which the ball travels a horizontal distance of 41 m before being caught. If the ball was kicked at an angle of 40 degrees above the horizontal, what was the initial speed?
7. A uniform rod of length L and mass M is free to rotate on a frictionless shaft through one end. The rod is released from rest in the horizontal position. What is the angular speed in radians per second of the rod at its lowest position? The moment of inertia about the shaft is $I = ML^2/3$.
8. An organ pipe has a length of 1.23 m. The pipe is open at both ends. If the speed of sound in air is 343 m/sec, what is the frequency of the fundamental, sometimes called the first harmonic?
9. The amount of solar energy delivered to a horizontal surface is on average 160 watts/ m^2 . Assuming 10% efficiency for absorption and conversion to usable heating, how many liters of water can be heated from zero degrees C to 20 degrees C in a 24 hour period by a 3 m^2 solar panel? The specific heat of water is 4185 J / kg K.
10. Give two statements of the second law of thermodynamics.
11. A sailor wants to travel due east at a velocity of 10 km/h with respect o a coordinate system fixed on land. The gulf stream is moving north at 4 km/h. With what speed with respect to the water should the sailboat proceed?
12. A playground rotating disk of diameter 4 m and rotational inertia 200 kg m^2 is going around at 3 rad/sec with no one on it. Two children of mass 15 kg each, jump on the edge of the disk. What is the new angular speed?
13. If the earth has mass M and a satellite is in circular orbit a distance R from the center of the earth, and the gravitational constant is G, derive the magnitude of the satellite velocity v in terms of G,M, and R.

Answers

1. Mgh = Fd; F = mgh/d ~ 6.5 x 10^3 N
2. For the initial P perpendicular to ground, P_1 = 0.6 x 5.4 x cos 65 deg. Then ΔP = twice this in magnitude or 2.7 kg m/sec
3. PN = NkT; N = PV/kT; substituting and remembering 6 liters = 6 x 10^{-3} m^3, and 20% factor, N_{Oxygen} ~ 2.9 x 10^{22}
4. Draw FBD. The torque exerted by gravity is T = LMgsinθ = in magnitude to: Moment of Inertia (I) x second derivative of θ, or α. Use small angle approx so sin becomes the angle. The moment of inertia is in this case ML^2 . Then magnitude of LMgθ ~ magnitude of ML^2 α. The M's cancel, and the value of ω~square root g/L. Then T ~ 2π square root L/g
5. Wt. crown = 1.3 x 9.8 = 12.74 N; Wt water displaced = 12.74 N – 11.17 N = 1.57 N = wt water displaced. M water displaced then = 0.16 kg. Since the density of water is 1000kg/m^3 the volume of water displaced is 1.6 x 10^{-4} m^3 . Then density of crown = 1.3 kg / 1.6 x 10^{-4} m^3 or 8.1 x 10^4 kg/m^3 , Give students the density of water.

   This is much less than the density of gold which is given by 19.3 kg/m^3 . So someone is cheating the king.

6. V_0 sinθ = $gT_{1/2}$; T = $2V_0$ sinθ / g . Then range R = T V_0 cosθ = $2V_0^2$ sinθcosθ/g Solve for V_0 = 20 m/sec
7. ΔP.E. = MgL/2 = 1/2x(ML^2/3)x ω^2 . Solve for ω = squareroot 3g/L
8. V = 2L f; f = 139 Hz
9. Q = 160 W/m^2 x 3 m^2 x 0.10 efficiencyx 24 x 3600 sec in 24 hr ~ 4.1x 10^6 joules. 1 liter = 1000 g = 1 kg. (Again, give density of water.) Then N liters ~ 48.
10.
11. By Pythagorean theorem v ~ 10.7 m/sec
12. $I\omega_1 = (I + 2mR^2)\omega_2$ Solve for ω_2 keeping in mind R = 2 m
13. $mv^2/R = G\,mM/R^2$; solving v = square root GM/R