Nov. 2015

Physics 1307 Examination 3

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Fall 2015

Please PRINT your name so that we can read it.

Name: Solutions

BOX your final answers.

SHOW work for maximum credit.

Think carefully ... but not too slowly!

Q1. 2 pts Recall that the moment of Inertia I of a uniform solid sphere is $I = (2/5)MR^2$, where M is the mass of the sphere and R is its radius. If you measure the moon's moment of inertia and then divide my its MR^2 you get the quantity $I/MR^2 = 0.394$, a pure number. If you do the same simple calculation for Earth, you get a somewhat different ratio $I/MR^2 = 0.33$. Since both the moon and Earth are spheres to a very good approximation, what do these 2 ratios tell you about how mass is distributed within each of these bodies? Circle the single best answer.

a) The moon does not at all have its mass very uniformly distributed;
b) Earth's mass is not quite uniform but tends to favor smaller radii;
c) Earth's mass is not quite uniform but tends to favor larger radii;
d) The moon is made from cheese.

Q2. 2pts You have 2 identical see-saws, one on Earth and one on the moon, where the acceleration due to gravity is much weaker than on Earth. Two objects of different mass are placed on the Earth see-saw so that it balances level. The same objects are placed in the same positions on the moon see-saw as they were on Earth. What happens? Circle the single best answer.

a) The side with the larger mass droops because of the smaller value of g.
b) The side with the smaller mass droops because of the smaller value of g.
c) The moon see-saw balances level.
d) None of the above answers is correct.

Q3. 2 pts You organize a race down a ramp between two barrel racers. Each of the barrels has the same mass and the same radius. Barrel Alphonse has some moment of inertia I_A. Barrel Carolyn has a moment of inertia $I_c = 0.5I_A$. If the two barrels start at the top of the ramp from rest and roll down, who, if anyone, wins the race?

a) Alphonse wins;
b) Carolyn wins;
c) The barrels tie;
d) The winner depends on the steepness of the ramp.

Q4. 10 pts You drop a bottle (of beer?) on both Earth and the moon. You notice the acceleration due to gravity on the moon g_M is only 1/6 that of what it is on Earth, g_E. If you somehow determine that the moon's radius R_M is only 3/11 of the Earth's radius R_E (i.e. $R_M/R_E = 3/11$), what is the mass of the moon compared to that of Earth? The easiest way to do this is just determine the ratio R of the masses of the two bodies, $R = M_M/M_E$. **Hint:** You do not need to know details like actual masses and radii. Remember to box your answer.

$R_M = \frac{3}{11} R_E$ and $g_M = \frac{1}{6} g_E$

accel. due to gravity $= \frac{GM}{R^2}$

$$g_M = \frac{GM_M}{R_M^2} = \frac{1}{6}\frac{GM_E}{R_E^2} \quad \left(= \frac{1}{6} g_E\right)$$

$$\rightarrow R = \frac{M_M}{M_E} = \frac{R_M^2}{R_E^2} \cdot \frac{1}{6} = \frac{1}{6}\left(\frac{3}{11}\right)^2$$

$$\rightarrow \boxed{\frac{M_M}{M_E} = \frac{3}{242} \approx 0.0124}$$

Q5. 10 pts You have given up on school and become an enthusiastic pirate. In your new employment, you are rolling a barrel of gunpowder up a ramp to be used for the cannons on your pirate ship. The barrel has a mass m_b = 50 kg, a radius r = 0.5m and the ramp is a height h = 3m above the dock. As you get to the top of the ramp, you pause for a second and then your parrot bites you in the ear.) The pesky bird will soon be this evening's meal.) Afterwards, the barrel rolls down the ramp from rest onto the dock and continues rolling, people scattering out of the way. Once it reaches the level dock, how long does it take the barrel to roll a horizontal distance s = 10m? You can assume the barrel does not slow appreciably during its time on the dock and acts like a solid, uniform cylinder. Recall that the moment of inertia I of a uniform, solid cylinder is $I = (1/2)MR^2$, where M and R have their typical meanings. Box your answer.

consv. of energy: $U_i = U_f$

$U_i = m_b g h$

$U_f = \frac{1}{2} M_b V_{com}^2 + \frac{1}{2} I_{com} \omega^2$

$= \frac{1}{2} m_b v^2 + \frac{1}{2}\left(\frac{1}{2} m_b R^2\right)\omega^2$

$(R\omega = v)$

$= \frac{1}{2} m_b v^2 + \frac{1}{4} m_b v^2 = \frac{3}{4} m_b v^2$

$\rightarrow \cancel{m}gh = \frac{3}{4}\cancel{m}v^2;$ (speed at bottom of ramp)

$v = \sqrt{\frac{4gh}{3}}$

$s = vt$

$t = \frac{s}{v} = (10\ m) \Big/ \sqrt{\frac{4(9.8 m/s^2)(3m)}{3}}$

$\boxed{t \approx 1.60\ s}$

Q6. 5 pts You are driving a car in a straight line at a speed $v = 10$ m/s on a level road. You release the gas pedal and coast to a stop, all the while continuing in a straight line. If the coefficient of (kinetic) friction μ_k between your tires and the road $\mu_k = 0.1$, how long T does it take you to stop? You need no further information to answer the problem and this is not really a question about friction. Take it from there and box that answer.

$$F\Delta t = m\Delta v$$

$$\rightarrow \quad t = \frac{m\Delta v}{F}$$

$$F = \mu_k N = \mu_k mg$$

$$t = \frac{m\Delta v}{\mu_k mg} = \frac{\Delta v}{\mu_k g} = \frac{(10\ m/s)}{(0.1)(9.8\ m/s^2)}$$

$$\boxed{t = 10.2\ s}$$

Q7. 10pts In Anchorage, collisions with a vehicle and a moose are so common that they are referred to with the abbreviation MVC. Suppose a car with mass m_c = 1,000kg collides with a moose of mass m_m = 500kg on a very slippery road, with the moose being thrown through the windshield (a common MVC result). What fraction f of the original kinetic energy is lost to other forms of energy?

conservation of momentum: $p_i = p_f$

$$p_i = m_c v_i = (m_c + m_m) v_f = p_f$$

$$m_c = 2m_m$$

$$\rightarrow \quad 2\cancel{m_m} v_i = 3\cancel{m_m} v_f$$

$$v_f = \frac{2}{3} v_i$$

$$K_i = \frac{1}{2} m_c v_i^2 = \frac{1}{2}(2m_m) v_i^2 = m_m v_i^2$$

$$K_f = \frac{1}{2}(m_c + m_m) v_f^2 = \frac{1}{2}(3m_m)\left(\frac{2}{3} v_i\right)^2 = \frac{2}{3} m_m v_i^2$$

$$\rightarrow \quad \frac{K_f}{K_i} = \frac{2}{3}$$

fraction energy lost, $f = 1 - \dfrac{K_f}{K_i} = 1 - \dfrac{2}{3}$

$$\boxed{f = \frac{1}{3}}$$

Extra credit. 1 pt. Give me a common English language word that has three consecutive pairs of duplicated letters. For example, the word "zookeeper" almost does it, except there is only one "k."

bookkeeper