

NYU General Physics 1—Problem set 5

Problem 1: A solid rubber ball of radius 1.5 cm is dropped from a height of 1 m onto a hard surface. It bounces. The objective of this problem is to figure out the magnitude of the contact force on the ball *during* the bounce.

(a) The contact force pushing the ball upwards will be far larger in magnitude than the gravitational force pushing the ball downwards. Explain why in words.

(b) Estimate the mass m of the ball and also the speed v at which the ball will be traveling just before it hits the floor. Use the internet or the library for the density of rubber.

(c) If the ball is in contact with the floor for about one millisecond, and if it bounces back upwards with about the “equal and opposite” velocity to that it had before the contact, what is the mean acceleration \vec{a} of the ball during the bounce?

(d) What is the implied mean contact force \vec{N} during the bounce?

(e) I said the ball will be in contact with the floor for ~ 1 ms. How could you estimate this? One option is to consider the time it takes a sound wave to traverse the diameter of the ball. Look up the speed of sound in rubber and estimate this time; is 1 ms reasonable? Also, can you think of other ways to make an estimate?

Problem 2: You are in the passenger seat of a car traveling fast in a straight line. You have your seatbelt on. The driver slams on the brakes, so you are accelerating with a magnitude of 12 m s^{-2} .

(a) If your mass is 50 kg, calculate and also draw all of the forces acting on your body during the acceleration (which most normal people would call “deceleration”).

(b) If the car plus contents has a mass of 1300 kg, what is the total force of the car on the road, from all four tires? Give direction and magnitude.

(c) If the road is slippery, the car will go into a skid. What is the critical coefficient of friction μ below which the car will slide?

Problem 3: When you are on a roller coaster, you feel heavier when the roller coaster goes through the bottom of a dip, and you feel lighter when the roller coaster goes over the crest of a hill.

(a) What force on your body in the roller coaster is larger at the bottom of a dip and what force is smaller at the top of the hill? Hint: It isn't the

gravitational force! Be sure to be able to explain *why* the force is different in the different cases.

(b) The astronauts in the Space Station feel weightless; why? Hint: It isn't because the gravitational force on them is small!