Additional PHYS2350 EV1 Fall 2017 Exam 2 Review Questions

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Chapter 5: Circular Motion & Gravity

1. A satellite is placed in orbit 6×10^5m above the surface of Jupiter. Noting that the mass of Jupiter is 1.90×10^{27}kg, and the radius is 7.14×10^7m, find the speed of the satellite.

2. A popular ride at amusement parks is one in which you lean against the wall of a cylindrical room which begins to rotate. At a high enough speed, you're pressed so firmly into the wall of the room that the floor can drop away and you won't fall (you're stuck to the wall, essentially). What force is responsible for producing your centripetal motion on the ride? What force is responsible for your not falling when the floor is dropped? If the room has a radius of 4m, and the walls rotate at a speed of 12m/s, how much centripetal force would a 65kg person experience on the ride?

3. Suppose someone were on a roller coaster going over a hill, and remained upright during the trip over the hill. If the speed going over the hill was 15m/s, the hill had a radius of curvature of 45m (that is, if it were a circle, its radius would be 45m), and the person's mass were 55kg, what would the apparent weight of the person be at the peak on the hill? To help visualize the problem, imagine the person were sitting on a scale. What would the scale read at the top of the hill? How fast would the roller coaster have to go for the person to be in danger of being thrown off?

4. A jogger is running around a 400m, circular track at a speed of 5m/s. What is the orbital period of the jogger around the track? How many laps can the jogger complete in one hour?

5. A newly discovered planet in some distance solar system orbits its star at roughly the same distance that we are from the Sun (in the so-called "habitable zone"). If the star that this planet orbits is half the mass of our Sun, but twice the radius, how long, in days, would a year be on that planet?

6. During an Olympic bobsled run, the Jamaican team rounds a corner of radius 8m at a speed of 30m/s. How many g's do they "pull" during this turn; that is, what is their centripetal acceleration in units of g?

7. How rapidly is the Earth accelerating towards the Sun? You may find it useful to know that 1 year is approximately $\pi \times 10^7$s, the mass of the Earth is 5.97×10^{24}kg, and the average distance between the Earth and the Sun is 1.5×10^{11}m.

Chapter 6: Work & Energy

1. A 50 kg child goes down a slide starting from a height of 1.2m. If the friction of the slide was just enough to keep the child at a constant speed down the slide, how much work would friction have done by the time the child hits the ground?

2. If it takes 185kJ of work to accelerate a car from 25m/s to 30m/s, what is the car's mass?

3. If a 2500kg car is moving at a speed of 25m/s when a dog suddenly runs out into the road and the driver slams on the brakes. In coming to a stop, how much energy was released as heat from the brakes, assuming that the car never changed altitude?

4. If a pitcher can throw a baseball with a force of 100N, and her hand travels a distance of 1.5m over the throw, what is the speed of the ball when it leaves her hand? Assume that the throw occurs along a straight path, and that the baseball has a mass of 150g.

5. Suppose a 60kg person could jump to a height of 35cm. How much work would the ground have to do on the person during the initial stages of the jump, prior to leaving the ground, in order for the person to jump this high?

6. A 50kg skateboarder skates through a course at a local park, beginning with a speed of 2.5m/s. Throughout the course, the skateboarder does an additional 70J of work by pushing himself along the ground with his foot and friction does a total of -250J of work on him. Consider both of these forces to be non-conservative. If the speed of the skateboarder is 6m/s at the end of the course, what was his total change in potential energy during the course? Is he above or below the height at which he began?

7. There was a very famous problem in physics, now known as the Brachistochrone problem, in which the goal was to find the shape of a downward curve that would allow an object to slide down under the influence of gravity in the least amount of time possible. This shape is known as a Brachistochrone, hence the name of the problem. The problem was solved by many prominent physicists at the time, including Isaac Newton, how had to invent a new form of mathematics for his solution. Without knowing anything about the shape of the curve, only that there is no friction on the surface, how fast will the object be going when it hits the bottom if it started out at a height of 20cm?

8. A 2000kg car drives up a hill, its engine doing 1×10^6J of work during the trip. If the car began at rest at sea level, and was moving at a speed of 25m/s after climbing a height of 150m, what is the total work due to all non-conservative forces *not ignoring air resistance or friction* on the car during the climb?

Chapter 7: Momentum

1. A 15kg object, moving at a speed of 12m/s, undergoes a perfectly inelastic collision with a 7kg object at rest. How much kinetic energy was lost by the system during the collision?

2. A bomb explodes in midair, sending a 100kg fragment at a speed of 50m/s at an angle of 28^o below the horizontal. At what speed would the rest of the fragmented bomb, with a mass of 135kg, move away from the explosion?

3. A 50N force is applied on a 40kg box for 2s. What is the box's gain in momentum during this push?

4. Two objects undergo a head-on collision after which they stick together. If one object had a mass of 1.5kg and was moving at a speed of 12m/s and the other had a mass of 2.7kg and was moving at a speed of 7m/s, what would the speed of the objects after the collision be? In which direction would they be moving: along the initial path of the 1.5kg or along the initial path of the 2.7kg object?

5. A 1500kg car, moving at a 10m/s, collides head on with a 2500kg truck moving at an unknown speed. If their wrecked cars move as one after the collision, and the slide to a stop over a distance of 15m under the influence of a 0.4 coefficient of kinetic friction, what was the speed of the truck just before the collision?

6. A super-bouncy ball is dropped from a height of 1.3m onto a floor. Assuming that the ball collides elastically with the floor, at what speed does the ball leave the floor? *Hint: use the formula specific for elastic collisions to solve this problem, not conservation of momentum.*

7. A bowling ball is tied to the end of a string and held at rest at a height of 2m. The bowling ball is to be dropped, swing towards a block of wood, and collide with the block of wood elastically at the bottom of its swing. If the bowling ball stops as a result of the collision, how much kinetic energy did the block of wood gain?

8. If a Boeing 747 engine can produce 250kN of thrust simply by moving air at around 170m/s through it. Considering that air has an average density of 1.2 kg/m^3, how many cubic meters of air must move through the engine per second in order to reach those thrust levels? In this case, note that

$$\frac{\Delta p}{\Delta t} = v\frac{\Delta m}{\Delta t}$$

and that the density is the amount of mass contained in 1 cubic meter of air (in these units).