Homework Assignment 2

Due: Tuesday, May 31, 2016

Problem 1: A cannon can fire a cannonball at a speed of 40 m/s. You're trying to take down a castle with the cannon from a distance of 80 m. The cannonball will be fired from the same height as the base of the castle. What is the range of angles (measured from the horizontal) at which you can fire the cannonball in order to achieve this? Find the minimum and maximum allowed angles. Notice that if the angle is too small or too large, the shot won't reach the castle. The castle is tall enough that you don't have worry about the cannonball going over the it. You may find the trignometric identity "$2\sin\theta\cos\theta = \sin(2\theta)$", and the graph of sine curve useful.

Problem 2: In the same situation as the previous problem, you decide to fire at an angle of 30° above the horizontal. [30° lies in the allowed range of angles.]

(a) At what height above the ground does the cannonball strike the castle wall?

(b) When it strikes the wall, is the cannonball on its way up, or on its way down?

Problem 3: Two airplanes take off from an airport at the same time. One flies at 800 km/h directly north and the other flies at 1000 km/h 30° west of south, both velocities measured with respect to the ground.

(a) After 5 hours of continuous flying, find the displacements (including the direction) of both the airplanes. Using this, find the distance between them.

(b) What is the speed of the second airplane relative to the first? Use this relative speed to find the distance between them after 5 hours of flying (since take off). Compare with your answer to (a).

Ignore the effects of earth's curvature. [We go back to the good old days when the earth was flat.]

Problem 4: You find yourself in a car chase in an action film! You are chasing the bad guys. Towards the end of the chase, there's a 10 m gap between them and you. You're travelling at a nerve-wracking 50 m/s while the bad guys are getting away at 55 m/s. As a last resort, you decide to fire a hook-gun at the other car. If the hook latches onto the other car, you can use lazy writing to quantum-electrically fry them. The hook-gun can shoot the hook at 45 m/s **(relative to the shooter)**. But the wire connecting the gun and the hook has a maximum length of 13 m, i.e., if the gap between the two cars goes beyond 13 m before the hook gets them, they'll get away.

In the course of answering this question, you'll see how this nailbiter ends. Ignore the size of the cars, i.e., don't worry about the length of your arm, the length of your car's hood, etc.

(a) What is the speed of the hook as seen by the bad guys?

(b) How long will it take the hook to reach the bad guys? [Don't worry about the length of the wire for this part.]

(c) When the hook reaches the bad guys according to (b), what is the distance between the two cars?

(d) Did you get them? [Use the length of the wire now.]

Problem 5: You're walking two dogs. A person on the other side of the street says "Who's a good boy?" (with the voice appropriate for the phrase) and one of your dogs loses it and tries to dart towards him. The other dog, decides to run straight down the road because he's not very smart. You hold your ground, so neither of the dogs can get away. If the first dog is exerting a force of 100 N on you in a direction 30° west of north, and the second dog is exerting 60 N directly north, what is the net force you're exerting on the dogs, i.e., the total force on both dogs combined? Give the magnitude and direction.

Problem 6: You want to throw a 1 kg object **vertically upwards**. You want to accelerate it from rest to 16 m/s within a distance of 1 m (after which the object will leave your hand). Assuming that the acceleration of the object is uniform, how much force are you exerting on the object during the throw? [Hint: Make sure you account for *all* the forces acting on the object.]

Problem 7: Two teams are playing tug of war. Team A has a combined mass of 300 kg and the team B has 320 kg. Assume that the rope is massless. Despite having a lesser combined weight, the team A is winning; the rope (and the two teams) are accelerating at 1 m/s^2 in team A's direction. If team A is exerting a force of 5000 N on team B (through the rope), how much force does team B exert on team A? How do you know this?

Problem 8: In the previous problem,

(a) Find the horizontal component of the contact force between the ground and team A.

(b) Find the horizontal component of the contact force between the ground and team B.

(c) Find the horizotal component of the total contact force between the ground and all the players (both teams combined), by adding the two forces together.

Problem 9: Now treat all the players involved (teams A and B combined) as one system. Applying Newton's 2$^{\text{nd}}$ law to this system, find the net horizontal force acting on it. Compare with your answer to Problem 8 (c). [Hint: Recall what the acceleration of this sytem is.]

Problem 10: An object of mass 10 kg is at rest on a rough horizontal surface while being pulled horizontally by a force of 10 N. ~~The coefficient of static friction μ_s between the surfaces in contact is 0.2, and the coefficient of kinetic friction μ_k is 0.18.~~ What is the magnitude of the frictional force in play? ~~Is it static or kinetic?~~