Physics 161, Homework 5

Due 12:00 pm, Friday, March 21; No Exceptions

Lubna Rana, Sections 0201-0206

Read Chapter 6, Sections 6.1-6.3 by Monday, March 17. Also, make sure you do all example problems in the chapter. Start Ch 7 after that.

Short Answer Questions: S1, S2, S3, S4,: Problems P1; P2 = Serway & Beichner Ch 6, P47; P2, P3, P4, P5, P6

Special Note: Please always:

1). PRINT your name and SECTION NUMBER CLEARLY on the front page of your HW. Failure to do so will now cost you points.

2). STAPLE all your pages. It is your responsibility to make sure that your hw gets submitted in one piece.

3). DO ALL THE PROBLEMS IN ORDER.

4). Show complete work and write logically consistent explanations for ALL PROBLEMS to receive credit.

5). Write units next to all dimensionful quantities.

Short Answer Questions

S0a). Make sure you have read the special notes 1-5 above.

S0b). A Note on Free-Body Diagrams & Problem Solving:

(1). The following problems **all** demand a **neat** and **carefully drawn** free body diagram. Remember that a free body diagram *isolates* each object of interest and shows forces acting only on it. In addition, an indication of your choice of coordinate system somewhere close to the free body diagram reduces the chance of mistakes.

2). Pick a convenient coordinate system, usually this turns out to be one in which one of the accelerations is along one of the axes. Indicate on your diagram which direction is positive x and which positive y.

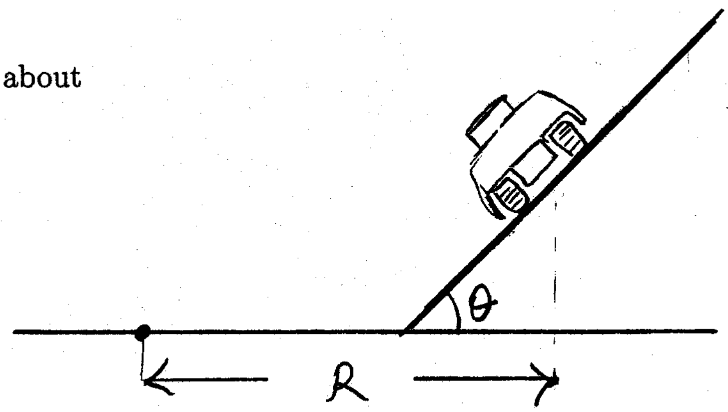
3). Decompose any forces that are not collinear with your axes into their x and y components.

4). Apply Newton's second law, ie, $F_{net,x} = ma_x$ and $F_{net,y} = ma_y$. Be extremely careful about the signs of all forces and accelerations. Be consistent with your coordinate system.

S1. A car is traveling away from us on a banked road having a curve of radius R. The coefficient of friction between the road and the tires of the car is **non-zero**. However, if the car travels at the *designated* speed, it does not have to rely on the friction to negotiate the curve. Draw a free body diagram of the car in the following three cases:

a). The car is traveling at a speed greater than the designated speed for which the banking angle θ has the optimum value. (Hint: Think about which way would the car slide if the road were frictionless.)

Fig S1.



b). The speed of the car is less than the designated speed for which θ is the optimum angle of banking. (Same hint as above).

c). The speed of the car is equal to the designated speed for which θ is the optimum angle of banking.

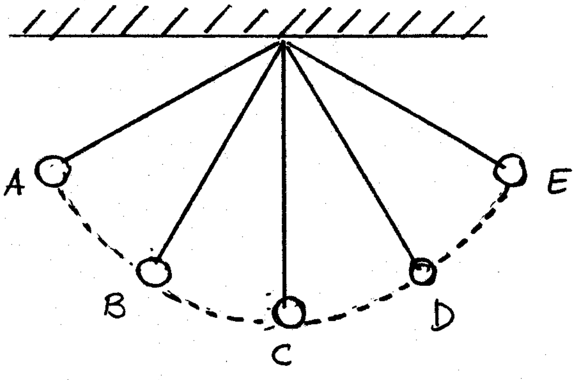
S2 A 150-lb student rides a ferris wheel that rotates at a constant rate. At the highest point, the seat exerts a normal force of magnitude 110-lb on the student. What would the magnitude of this normal force be at the lowest point? (An object with a mass of 1 kg weighs 2.2 lbs.)

S3). It is possible to twirl a bucket containing water in a vertical circle without the water spilling out. (a). What are the forces acting on the water at the highest point? (b). Why doesn't the water spill out?

S4). A bob of mass m swings from the end of a string. At point A the bob is at the extreme point of its swing and thus is instantaneously at rest. The bob then swings down to point C, then up to point E and back.

(a). Draw a free body diagram of the bob at points A, B, C, D and E.

(b). Draw a second diagram showing the **net force** on the bob at points A, B, C, D and E. (Use the fact that the bob's instantaneous velocity at A is zero.)



(c). Finally, draw a third diagram showing the **total acceleration** vector at points A, B, C, D and E. (Recall Exam I.) Which one of Newton's laws lets you go directly from your diagram in part (b) to that in part (c)?

Problems:

P1). A satellite in a circular orbit is a freely-falling object that happens to be moving at just the right speed so that the gravitational force acting on it provides exactly the right acceleration to hold it in its circular path.

a). With what speed v would an object have to travel to be in circular orbit just above the surface of the earth? What is the time T it takes the object to go around the earth at this speed?

b). How do your answers to part (a) change if the satellite is at some height h above the surface of the earth? Does v increase, decrease or stay the same? How about T.

c). How do your answers to both parts (a) and (b) change if the mass of the satellite is *doubled.*

P2. Serway & Beichner, Problem 47.

P3). A child places a lunch box on the rim of playground merry-go-round that has a radius R. If the speed of the merry-go-round is v, what must the coefficient of static friction between the box and the merry-go-round be if the box is to stay on?

P4. Imagine that you are driving on a large, dark parking lot in the middle of the night. Your headlights suddenly illuminate a wall directly ahead of you perpendicular to your direction of travel and stretching away on both sides as far as the eye can see. To avoid hitting the wall, is it better to turn your car to the right (or equivalently to the left) *without braking* or brake as hard as you can while moving *straight* toward the wall? (For this problem, you can assume that μ_s and μ_k are roughly equal. Note that this is only a good assumption if the answer does not change drastically if we don't make the assumption.)

b). If the wall is $50m$ away at the time you notice it, find a reasonable estimate for the maximum velocity one can be moving with at that time to prevent disaster.

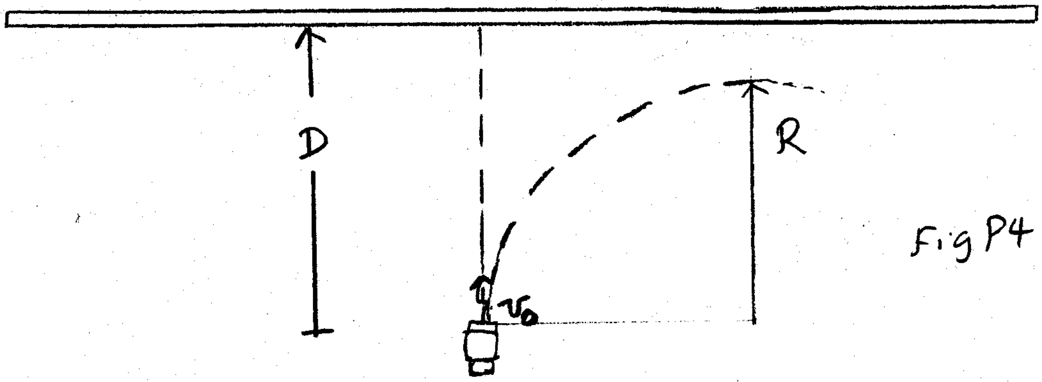


Fig P4.

P5. The figure below illustrates a man, of mass m suspended from a rope of length L, whose upper end is fastened to a ledge.

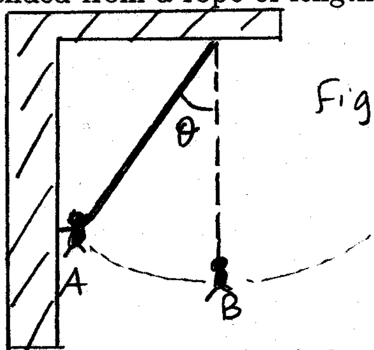


Fig P5.

a). Suppose that the man is at rest, holding on to a rock wall, while the rope makes an angle θ with the vertical. What then is the magnitude of the tension force exerted on the man by the rope?

b). What is the magnitude of this tension force when the man is still at point A, but immediately after he releases his hold from the wall?

c). What is the magnitude of this tension force at the instant when the man, while swinging, is reaches his maximum speed v_B at the bottom of the swing?

P6. A stunt pilot, strapped into the seat of his plane, travels with a constant speed v around a vertical circular loop of radius R. The mass of the pilot is m, the mass of the plane is M.

a). What is the force exerted on the pilot by the plane when the plane passes the lowest point of A of the loop? Can this force be directed upward? Can it be directed downward? Can it be zero? What must be the speed of the plane for any of these cases to be possible?

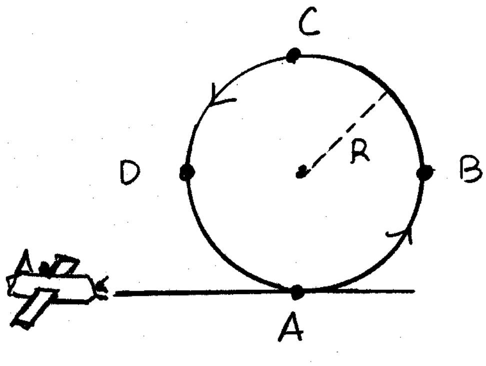


Fig P6.

b). What is the force exerted on the pilot by the plane when the plane passes the highest point C of the loop? Answer the same questions for this case as in part *a*.

c). Suppose the force exerted on the pilot by the plane is zero. Can this occur at point A or C? How large would the speed of the plane have to be if the radius R of the loop is $350m$?

d). Suppose the plane flies around this loop of radius $R = 350m$, with such a speed that the pilot's acceleration has a magnitude equal to $8g$. (This is close to the maximum acceleration a person can tolerate without losing consciousness.) What would be the speed of the plane?

e). What is the direction of the *total* force on the pilot when the plane passes point D?