

~~4.7 SHO - Tunnel through the Earth~~ page 410, problem 43. I did this problem on **PIVoT**.

~~4.8 Pendulum.~~ Watch **PIVoT**.

~~At the end of a string of length 2 m hangs a bob with a mass of 3 kg. The bob is released from rest with the string at 30° to the vertical [$g = 10 \text{ m/sec}^2$].~~

- ~~a) How fast is the bob moving at the bottom of the swing?~~
- ~~b) What is its kinetic energy at the instant when the string makes an angle of 10° to the vertical?~~
- ~~c) How would your answers under a) and b) change if the mass of the bob were 6 kg?~~

~~4.9 Work~~ page 178, problem 8.

~~4.10 Pushing a Box~~ page 178, problem 10.

~~4.11 Roller Coaster~~ page 182, problem 52. Watch **PIVoT** under roller coaster.

~~4.12 Horizontal spring with friction.~~ Watch **PIVoT** under friction (*Spring on Table with Friction*).

~~A 3.0 kg block rests on a leveled table. The coefficients of friction between the block and the table are $\mu_s = 0.30$ and $\mu_k = 0.20$. The block is attached to a wall by means of a horizontal spring of spring constant $k = 80 \text{ N/m}$. We pull on the block and stretch the spring and then let go with the block initially at rest. Use $g = 10 \text{ m/sec}^2$.~~

- ~~a) What is the maximum extension of the spring for which the block will remain stationary when released?~~
- ~~b) The block is placed in this position and then given a very gentle push towards the wall. At what position will the block reach its maximum speed?~~

~~4.13 Pendulum in action.~~ I did this problem on **PIVoT** under pendulum.

~~A pendulum consists of a "massless" string of length l and a bob of mass m . We release the bob (without speed) when the string is at an angle θ_0 with respect to the vertical. A pin is located a distance L below the top of the string. When the pendulum swings down, the string hits the pin.~~

- ~~a) What is the maximum angle α that the string below the pin makes with the vertical after hitting the pin?~~
- ~~b) If the bob had been released with an initial tangential velocity v_0 , what would then be the maximum angle α . Does the direction of this tangential velocity matter?~~

4.14 Drop suitcase on conveyor belt.

- a) A stationary suitcase is placed on a moving conveyor belt. Is the friction static or kinetic?
- b) The belt is moving to the right. Thus, relative to the belt, the suitcase is moving to the left, thus there is a force on the suitcase to the right. The suitcase accelerates to the right until it reaches the speed of the belt. Is the work that friction does on the suitcase positive, negative, or zero?
- c) After the suitcase reaches the speed of the belt, what is the horizontal component of the force acting on the suitcase?

Reminder.

~~There are 25 recitation sections. If you want to change, for whatever reason, please go to the physics education office (4-352).~~

~~(We must be careful here. If $|v_0|$ is too large or if $|\theta_0|$ is too large then the bob will complete a full ‘loop’ about the pin; and our above result will be incorrect. This problem will occur when the above equation indicates that $\cos \alpha < -1$.)~~

~~The dependence of α on v_0 is quadratic, i.e. the sign of v_0 does not seem to matter. Physically there are three different cases for the motion:~~

~~(1) The bob moves immediately toward the pin, strikes the pin, and then moves to the maximum angle α ;~~

~~(2) The bob initially moves away from the pin, the value of v_0 was large enough that the bob can complete a full ‘loop,’ the bob strikes the pin from the other side, and then moves to the maximum angle α ;~~

~~(3) The bob initially moves away from the pin, the value of v_0 was *not* large enough that the bob can complete a full ‘loop,’ at some point the bob swings back toward the pin as for case (1), strikes the pin, and then moves to the maximum angle α .~~

~~(Note that there is a case between (2) and (3) in which the bob moves partly around the ‘loop’ but drops during the process. If we ignore any energy that is lost during the bouncing then even this case will eventually swing to the maximum angle α .)~~

Problem 4.14 (Ohanian, page 182, problem 52)

(a) Initially, the suitcase is ‘stationary,’ and the conveyor belt is ‘moving.’ Thus there is relative motion between the two, and the friction is kinetic.

(b) Friction always opposes the *relative* motion, but depending on the frame of reference, friction may or may not be aligned with the motion in that frame. To see this most clearly, we will use two frames of reference to answer this question.

First, imagine the situation from the perspective of the conveyor belt. The suitcase is moving left, and the conveyor belt is stationary. The suitcase slams onto the conveyor belt, and skids until it stops. The direction of friction, which caused the skidding, and the apparent direction of motion are opposite. Clearly friction did negative work: initially there was kinetic energy, and eventually there was none.

Now, imagine the situation from the perspective of a person standing next to the conveyor belt. The suitcase is initially stationary, and the conveyor belt is moving right. The suitcase lands on the conveyor belt, and accelerates right until its speed matches the speed of the conveyor belt. The direction of friction, which caused the acceleration, and the apparent direction of motion were the same. Clearly friction did positive work: initially there was no kinetic energy, and eventually there was a non-zero kinetic energy.

The conclusion is that work is a quantity that depends on the frame of reference.

(c) Presumably the conveyor belt is moving at a constant speed. If the suitcase has reached the speed of the conveyor belt then it too has a constant speed, thus the net horizontal force must be zero. If the conveyor belt and suitcase have identical velocities, then there is no relative motion and no force attempting to cause relative motion; therefore there is no friction.