Minds•On Physics Activity

101

Solving More Complex Problems

Purpose and Expected Outcome

Not all problems require exactly one principle to solve. Some require two or even three to solve. Other problems require a more careful analysis of the concepts involved than most. In this activity, you will learn how to apply concepts and principles more thoroughly to different types of problems.

Prior Experience / Knowledge Needed

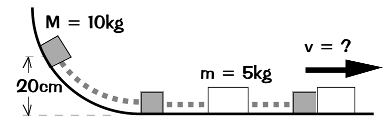
You should be familiar with all the concepts, principles, and operations needed to solve problems in mechanics. You should know how to determine which principles apply to a problem situation, and how to choose the most appropriate principle.

SOLVING COMPLEX PROBLEMS

There are a number of ways that a problem can be made complex. Before solving some of them, it might help you to see some of the different types.

Sequential many-principle problems. Perhaps the simplest type of complex problem is one in which the process described can be broken down into a number of one-principle problems. The key to solving this type is recognizing each of the sub-processes going on within the problem. Consider the following problem:

> A 10kg block slides frictionlessly from a height of 20cm, starting from rest. It collides and sticks to a 5kg block. What is the speed of the pair after the collision?



This problem is really two problems put together. The collision at the end of the process conserves momentum, but we cannot determine the final speed without knowing the speed of the 10kg block before the collision. This is found by applying Conservation of Energy using the height from which it was released. Then we can use Conservation of Momentum to find the desired quantity.

Simultaneous many-principle problems. In this type, two or more principles must be applied at the same time. For instance, when a spring is used in a collision or in an "explosion", both energy and momentum are usually conserved during the interaction, and often, both must be applied to solve for the desired unknown.

Given information not suggestive of relevant concepts. What if you were given a graph of acceleration vs. position? How would you interpret it? How would you use it to analyze the situation? What principle is suggested by this graph? You probably have not ever seen a graph like this, but what happens if you multiply the acceleration by the mass of the object? This is the net force exerted on the object! And a graph of net force vs. position is often used to find the total work done an object. Therefore, even though the given information is highly suggestive of kinematics, in fact, the more relevant concepts might involve dynamics and energy instead.

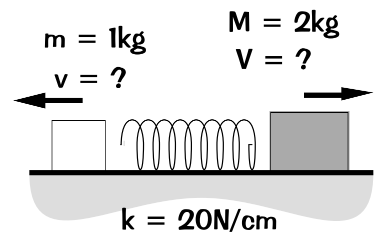
Desired unknown not suggestive of relevant concepts. Re-consider the problem above. What if the question asked for the kinetic energy of the pair after sticking together? This is suggestive of energy concepts as being most relevant, but momentum conservation is needed to solve it. You must determine the final speed of the pair first, then apply the definition of kinetic energy to answer the question.

In general, try not to be misled by what is given or what is asked for, focus on the principles that can be applied, and try to break down the problem as much as possible before solving it.

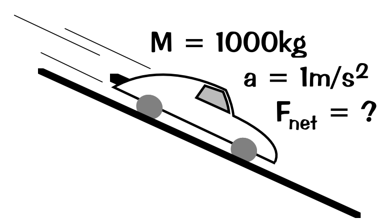
Explanation of Activity

In this activity, you will solve 6 problems. We encourage you to think about <u>what</u> principles apply, <u>why</u> they can be validly applied, and <u>how</u> you will apply them before solving each problem.

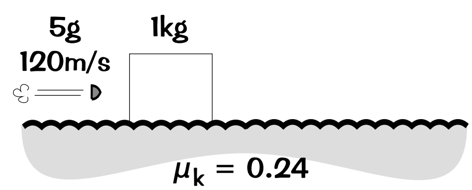
A1. Two wooden blocks are used to compress a spring by 3cm. Neither block is attached to the spring, and both are released from rest. What are their speeds just after losing contact with the spring?



A2. A 1000kg sports car is attempting to stop at the bottom of a steep 30° hill. If the maximum rate possible under these conditions is $1 m/s^2$, what is the force of friction on the car while it is stopping? (Ignore air resistance.)

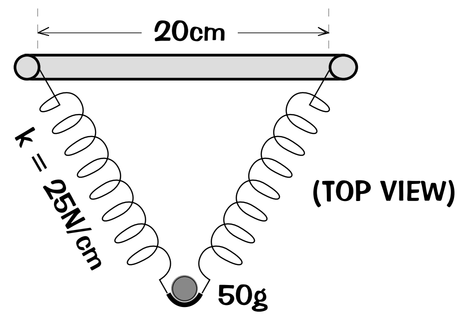


A3. A 5g bullet is shot at 120m/s into a 1kg block as shown. Estimate how far the block slides before stopping.

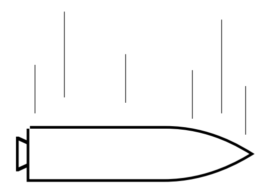


continued

A4. A slingshot is made by attaching 2 identical 5cm springs to two posts separated by 20cm as shown. A 50g metal ball is placed between the two springs and stretched until <u>each spring</u> is 20cm long. If the ball is released from rest, estimate its maximum speed.



A5. A 20,000kg rocket is drifting in space at 80m/s as shown. At some point, the engines are fired to produce a force of 120,000N for 10s. What is the speed of the rocket at the end of the 10s time period?



A6. A 20kg cannon ball is shot at 40m/s at an angle of 75°. At the top of its trajectory it explodes into two pieces, one of which falls straight to the ground. The other is observed to travel horizontally at 50m/s just after the explosion. What are the masses of the two fragments?