Discussion Problem #1:

In a weak moment you volunteered to be a human cannonball at an amateur charity circus. The "cannon" is actually a 3-foot diameter tube with a big stiff spring inside which is attached to the bottom of the tube. A small seat is attached to the free end of the spring. The ringmaster, one of your soon to be ex-friends, gives you your instructions. He tells you that just before you enter the mouth of the cannon, a motor will compress the spring to 1/10 its normal length and hold it in that position. You are to gracefully crawl in the tube and sit calmly in the seat without holding on to anything. The cannon will then be raised to an angle such that your speed through the air at your highest point is 10 ft/sec. When the spring is released, neither the spring nor the chair will touch the sides of the 12-foot long tube. After the drum roll, the spring is released and you will fly through the air with the appropriate sound effects and smoke. With the perfect aim of your gun crew, you will fly through the air over a 15-foot wall and land safely in a net. You are just a bit worried and decide to calculate how high above your starting position you will be at your highest point. Before the rehearsal, the cannon is taken apart for maintenance. You see the spring, which is now removed from the cannon, is hanging straight down with one end attached to the ceiling. You determine that it is 10 feet long. When you hang on its free end without touching the ground, it stretches by 2.0 ft. Is it possible for you to make it over the wall?

Discussion Problem #2:

Because of your physics background, you have been hired as a technical advisor for a new James Bond adventure movie. In the script, Bond and his latest love interest, who is 2/3 his weight (including skis, boots, clothes, and various hidden weapons), are skiing in the Swiss Alps. She skis down a slope while he stays at the top to adjust his boot. When she has skied down a vertical distance of 100 ft, she stops to wait for him and is captured by the bad guys. Bond looks up and sees what is happening. He notices that she is standing with her skis pointed downhill while she rests on her poles. To make as little noise as possible, Bond starts from rest and glides down the slope heading right at her. Just before they collide, she sees him coming and lets go of her poles. He grabs her and they both continue downhill together. At the bottom of the hill, another slope goes uphill and they continue to glide up that slope until they reach the top of the hill and are safe. The writers want you to calculate the maximum possible height that the second hill can be relative to the position where the collision took place. Both Bond and his girlfriend are using new, top-secret frictionless stealth skis developed for the British Secret Service.

Discussion Problem #3:

Because of your physics background, you have been able to get a job with a company devising stunts for an upcoming adventure movie being shot in Minnesota. In the script, the hero has been fighting the villain on the top of the locomotive of a train going down a straight horizontal track at 20 mph. He has just snuck on the train as it passed over a lake so he is wearing his rubber wet suit. During the fight, the hero slips and hangs by his fingers on the top edge of the front of the locomotive. The locomotive has a smooth steel vertical front face. Now the villain stomps on the hero's fingers so he will be forced to let go and slip down the front of the locomotive and be crushed under its wheels. Meanwhile, the hero's partner is at the controls of the locomotive trying to stop the train. To add to the suspense, the brakes have been locked by the villain. It will take her 10 seconds to open the lock. To her horror, she sees the hero's fingers give way before she can get the lock off. Since she is the brains of the outfit, she immediately opens the throttle causing the train to accelerate forward. This causes the hero to stay on the front face of the locomotive without slipping down, giving her time to save the hero's life. The movie company wants to know what minimum acceleration is necessary to perform this stunt. The hero weights 180 lbs in his wet suit. The locomotive weighs 100 tons. You look in a book giving the properties of materials and find that the coefficient of kinetic friction for rubber on steel is 0.50 and the coefficient of static friction is 0.60.

Discussion Problem #4:

While working in a University research laboratory, you are given the job of testing a new device for precisely measuring the weight of small objects. The device consists of two very light strings attached at one end to a support. An object is attached to the other end of each string. The strings are far enough apart so that objects hanging on them don't touch. One of the objects has a very accurately known weight while the other object is the unknown. A power supply is slowly turned on to give each object an electric charge which causes the objects to slowly move away from each other (repel) because of the electric force. When the power supply is kept at its operating value, the objects come to rest at the same horizontal level. At that point, each of the strings supporting them makes a different angle with the vertical and that angle is measured. To test the device, you want to calculate the weight of an unknown sphere from the measured angles and the weight of a known sphere. You use a standard sphere with a known weight of 2.000 N supported by a string which makes an angle of 10.0^{o} with the vertical. The unknown sphere's string makes an angle of 20.0^{o} with the vertical.

Discussion Problem #5:

Because of your knowledge of physics, and because your best friend is the third cousin of the director, you have been hired as the assistant technical advisor for the associate stunt coordinator on a new action movie being shot on location in Minnesota. In this exciting scene, the hero pursues the villain up to the top of a bungee-jumping apparatus. The villain appears trapped, but to create a diversion she drops a bottle filled with a deadly nerve gas on the crowd below. The script calls for the hero to quickly strap the bungee cord to his leg and dive straight down to grab the bottle while it is still in the air. Your job is to determine the length of the unstretched bungee cord needed to make the stunt work. The hero is supposed to grab the bottle before the bungee cord begins to stretch so that the stretching of the cord will stop him gently. You estimate that the hero can jump off the bungee tower with a maximum velocity of 10 ft/sec straight down by pushing off with his feet and can react to the villain's dropping the bottle by strapping on the bungee cord and jumping in 2 seconds.