Behavior of the Simple Pendulum

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Topic

The behavior of the simple pendulum

Time

15 minutes for preparation, 40 minutes to completion

Safety

Please click on the safety icon to view the safety precautions. Use caution while piercing the hole in the film canister cap.

Materials

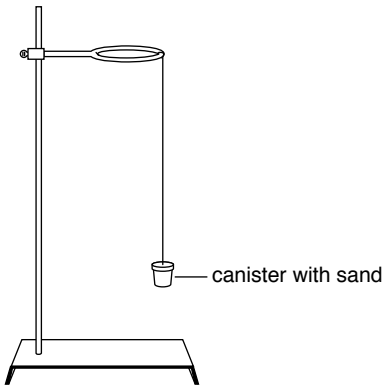
35-mm film canister with cap (plastic)
stickpin
wood block
heavy thread
sand
apparatus from which to hang pendulum (a coat hook will do if pendulum can swing freely)
protractor
watch with a second hand

Procedure

1. Assemble the pendulum as follows: Remove the plastic cap from the film canister. Place it on the wood block. Carefully pierce the center of the cap using the stickpin.
2. Put one end of a 60-cm (2-ft) length of thread through the top of the cap. Tie a knot in the thread on the bottom of the cap so that it cannot be pulled out of the cap.
3. Fill the canister one-third full of sand, and replace the cap with the thread through it.
4. Attach the pendulum to the apparatus you have chosen to hold it (see figure). Make sure that the canister can swing freely. Measure and carefully record the length of the string from contact with apparatus to canister.
5. Start the pendulum swinging through an arc of between 10 degrees to 15 degrees, as measured from the vertical with your protractor. As you let go of the canister, carefully record the time on your watch.

DATA TABLE				
Trial	Original setup (length 4)	Amplitude change	Length change (length 4)	Mass change
1				
2				
3				
4				
5				
Average				

6. Count through 20 complete swings of the pendulum, and again carefully record the time. (You take 20 swings because the time for one swing is too small to measure reliably.) Subtract the starting time from the final time to obtain the time it took for 20 complete swings. Record this time in the first box of the data table opposite "Trial 1."
7. Repeat this measurement 4 more times, each time recording on the data table the time it takes for 20 complete swings.



8. Take the average of the five trials. This will be the time you compare with times that result from changes in the experimental setup.
9. Do steps 5 to 8 again, but increase the amplitude of the swing by starting it from an angle of between 20 degrees to 25 degrees. Compare the average time for 20 swings with the two different amplitudes.
10. Do steps 5 to 8 again, with the original amplitude, but this time lengthen the string by 15 cm (6 in.). Measure and record the new length of the pendulum. Compare the average time for 20 swings with the two different pendulum lengths.
11. Using the original amplitude and string length, do steps 5 to 8 again, but this time fill the canister two-thirds full of sand. Compare the average time for 20 swings with the two different masses. You have now tested differences in amplitude, pendulum length, and mass.

12. What conclusions can you come to concerning the effects of the changes in amplitude, pendulum length, and mass on the period of the pendulum?

What's Going On

The calculation $g = 4\pi r^2$/slope should give a value of g close to 9.8 m/sec^2, the generally accepted value of g. The range of error should be from about 9.2 m/sec^2 to 10.1 m/sec^2 if the procedure is done very carefully. The largest error is in timing the pendulum's 10 swings. There is also some error in measuring the length of the pendulum.

Connections

Galileo is supposed to have been fascinated by the motion of a chandelier hanging in a cathedral. His observations led him to conclude that the time it takes for a pendulum to make a complete swing does not depend on how wide a swing it makes. In other words, the period (time it takes for one complete swing) is independent of the amplitude (size of the swing). Galileo's observations apply to small amplitudes. In this experiment, you examined the behavior of a simple pendulum and tested Galileo's conclusion. When the amplitude is small, the period of a pendulum's swing is dependent on length but not on mass or specific amplitude.

Safety Precautions

READ AND COPY BEFORE STARTING ANY EXPERIMENT

Experimental science can be dangerous. Events can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. Basic safety procedures help prevent serious accidents. Be sure to follow additional safety precautions and adult supervision requirements for each experiment. If you are working in a lab or in the field, do not work alone.

This book assumes that you will read the safety precautions that follow, as well as those at the start of each experiment you perform, and that you will *remember* them. These precautions will not always be repeated in the instructions for the procedures. It is up to you to use good judgment and pay attention when performing potentially dangerous procedures. Just because the book does not always say "be careful with hot liquids" or "don't cut yourself with the knife" does not mean that you should be careless when simmering water or stripping an electrical wire. It *does* mean that when you see a special note to be careful, it is extremely important that you pay attention to it. If you ever have a question about whether a procedure or material is dangerous, stop to find out for sure that it is safe before continuing the experiment. To avoid accidents, always pay close attention to your work, take your time, and practice the general safety procedures listed below.

PREPARE

- Clear all surfaces before beginning work.
- Read through the whole experiment before you start.
- Identify hazardous procedures and anticipate dangers.

PROTECT YOURSELF

- Follow all directions step by step; do only one procedure at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure that there is adequate ventilation.
- Do not horseplay.
- Wear an apron and goggles.
- Do not wear contact lenses, open shoes, and loose clothing; do not wear your hair loose.
- Keep floor and work space neat, clean, and dry.
- Clean up spills immediately.
- Never eat, drink, or smoke in the laboratory or near the work space.
- Do not taste any substances tested unless expressly permitted to do so by a science teacher in charge.

USE EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives and other sharp or pointed instruments with caution; always cut away from yourself and others.
- Pull plugs, not cords, when inserting and removing electrical plugs.
- Don't use your mouth to pipette; use a suction bulb.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
- Clean up broken glassware immediately.

- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use only low-voltage and low-current materials.
- Be careful when using stepstools, chairs, and ladders.

USING CHEMICALS

- Never taste or inhale chemicals.
- Label all bottles and apparatus containing chemicals.
- Read all labels carefully.
- Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING INSTRUCTIONS

- Use goggles, apron, and gloves when boiling liquids.
- Keep your face away from test tubes and beakers.
- Never leave heating apparatus unattended.
- Use safety tongs and heat-resistant mittens.
- Turn off hot plates, bunsen burners, and gas when you are done.
- Keep flammable substances away from heat.
- Have a fire extinguisher on hand.

WORKING WITH MICROORGANISMS

- Assume that all microorganisms are infectious; handle them with care.
- Sterilize all equipment being used to handle microorganisms.

GOING ON FIELD TRIPS

- Do not go on a field trip by yourself.
- Tell a responsible adult where you are going, and maintain that route.
- Know the area and its potential hazards, such as poisonous plants, deep water, and rapids.
- Dress for terrain and weather conditions (prepare for exposure to sun as well as to cold).
- Bring along a first-aid kit.
- Do not drink water or eat plants found in the wild.
- Use the buddy system; do not experiment outdoors alone.

FINISHING UP

- Thoroughly clean your work area and glassware.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Don't dispose of materials in the sink unless instructed to do so.
- Wash your hands thoroughly.
- Clean up all residue, and containerize it for proper disposal.
- Dispose of all chemicals according to local, state, and federal laws.

BE SAFETY-CONSCIOUS AT ALL TIMES