

## How is Change in Motion Connected to Acting Force?

In order to set an object in motion (or change the state of motion in general), we need a force acting on the object. What do we measure if we hang a weight on a dynamometer, and we move the dynamometer up and down a) quickly or slowly, b) in water or in the air?

### What you need:

- [Vernier DFS-BTA](#) dynamometer
- an empty tube of fizzing tablets (e.g. Berocca)
- pebbles, screws or other weights you can put into the tube
- a string
- a ruler
- a graduated cylinder high enough, so that you can fit the tube of fizzing tablets into it



### Tasks:

#### Estimation of measurement results

Before conducting the measurement, read the procedure and estimate the results. Try to sketch on a piece of paper the time dependence of the force acting on the hook of the dynamometer during the whole measurement. These initial concepts may differ; try to get to a solution that everybody agrees with by mutual discussion.

Based on your first measurement, you can change your estimation of the result of the second measurement before conducting it, if you like.

#### Preparation before measurement

1. Put some pebbles or screws and nuts (or other weights) into the tube of fizzing tablets so that it sinks if immersed in water.
2. Attach a string to the tube so that it is possible to fasten it to the dynamometer.
3. Insert tube hanging on the string to the bottom of the graduated cylinder and fill the cylinder with enough water so that the water level is several centimetres below the rim of the cylinder.
4. Pull out the tube and dry it.
5. Switch the dynamometer to a higher range (to 50 N).
6. Connect the dynamometer to you computer and run the Vernier Logger Lite programme.
7. Set the Sampling Rate to 50 Hz and check *Continuous Data Collection*.

#### Measurement in the air

1. Place the dynamometer in a vertical position with the hook facing down and set it to zero (*Experiment > Zero*).
2. Hang the tube on the hook of the dynamometer and start the measurement. The programme starts to plot a graph of the force acting on the dynamometer vs. time. Before performing any changes in motion, wait until the time reaches 10 seconds, 20 seconds, 30 seconds and 40 seconds.
3. At 10 seconds after the start of the measurement move the tube ca. 10 cm higher in about one second.
4. Wait for 10 seconds and again at 20 seconds after the start of the measurement move the tube ca. 10 cm higher, but do it slowly (for about 5 seconds) this time.
5. At 30 seconds after the start move the tube 10 cm lower in about 1 second.
6. At 40 seconds move the tube 10 cm lower (approximately back to the starting position) in 5 seconds.



7. Stop the measurement and click *Experiment > Store Latest Run*.
8. Compare your estimation (a graph that you sketched before the measurement) with reality. If your graph differs in some parts, try to explain why.
9. If you corrected or clarified some of your misconceptions after this measurement, you can, before conducting the second measurement, change your estimation of the time dependence of the force acting on the dynamometer when you move the tube up in water.

### Measurement in water

1. Hang the tube on the dynamometer and place the tube on the bottom of the graduated cylinder filled with water.
2. Start the measurement.
3. Pull the tube slowly and uniformly upward until it is fully out of the water. Continue until it is about 10 cm above the water level.
4. Stop the measurement and click *Experiment > Store Latest Run*.
5. Compare your estimation (a graph that you sketched before the measurement) with reality. If your graph differs in some parts, try to explain why.



Modul PHYSICS

Worksheet for students

