Motion

Objective

The purpose of this experiment is to examine the concept of uniform motion, calculate average speed, and develop an understanding of accelerated motion.

Materials

1. Ball bearing and pencil location marker
2. Corks
3. Grooved track with support blocks
4. Large metal spring scale (for room)
5. Masking tape
6. Ruler
7. Skateboard
8. Spring scale (x2)
9. Stopwatch

Background Information

The speed of an object is the distance covered divided by the time it takes to cover that distance. Velocity is speed and direction, i.e. a speed in a particular direction. An object moving with constant velocity has uniform speed in a straight line. [Q1] What must be true about the distances covered in equal time periods if an object has constant velocity?

Procedure

Most of this experiment will require fairly large groups of about five. For the final part involving measurements on a moving person the whole class will work as one large group in taking the data.

Part 1: Uniform Velocity

Set up the grooved track so that a ball bearing will move with uniform speed. Adjust the height of the track at one end to control the speed of the ball—the friction of the track is acting against its motion, so you have to raise it to a height where gravity can provide acceleration approximately equal to the friction. The grooved track has a metric tape on the side. Let one person start the ball with the others serving as timekeepers. Collect data to show that the ball bearing is moving at constant velocity.

[D1] Describe how you know the motion on the track is uniform velocity. Be sure your description could convince someone else that the velocity is uniform. [Q2] What is the speed of the ball in cm/s? ... in m/s?

Part 2: Unknown Position

Using the same setup as for part one, place one marker 20 centimeters from one end of the track. Place a second marker 30 centimeters from the first marker with one timekeeper assigned to each of these markers. Roll the bearing from the top end of the track. Both timekeepers should start their stopwatches when the bearing passes the first marker. The first timekeeper should stop his/her stopwatch when the bearing passes the second marker. The second timekeeper should stop his/her stopwatch at a position that has been selected by him/her and not revealed to the other partners.

Record the following data:

- T_b – the time when bearing passed second marker,
- T_c – the time reported by second timekeeper when ball passes his/her secret position, and
- D – the distance from first marker to second.

[Q3] Using these data, calculate the position of the bearing when the second timekeeper stopped his/her stopwatch. [D2] Write a description of how your determined the position. [D3] Compare this prediction with the actual position as now reported by the second timekeeper.

Repeat this Part with two additional and different unknown positions.

Part 3: Accelerated Motion

Raise one end of the grooved track several centimeters. Measure this additional height. Assign a timekeeper to various positions along the track, for example 20 cm, 40 cm, 60 cm. Hold the bearing at the upper end of the track and start all stopwatches as it is released. Each timekeeper should stop his/her watch as the ball passes their assigned mark. You may need to practice this procedure. Change the angle of the board, and repeat the activity.

Record a table of distance versus time. [D4] What happened to the velocity of the bearing as it rolled down the track? [D5] How do you know? [D6] Is there anything uniform about what happened to the velocity each second? [D7] How do the velocities of the bearing compare when the board is at different heights? [D8] How can you explain this? The graph you are about to draw may help you with these questions.

Using the data collected above plot a graph of position vs time. With appropriate choice of scale you should be able to get the plots for both heights on the same graph. [D9] Is there a linear relationship between distance and time—i.e., does the object travel twice as far if the time is doubled? If your graph is not a straight line try plotting distance versus square root of time, distance versus time squared, etc. If you obtain a straight line, [Q4] compute the slope and [D10] write the math sentence that describes your data.

Part 4: Skateboard Velocity

Now we will make time and distance measurements for a moving person. Locate a person with a stopwatch at each of the positions along the track marked off in the hallway. One student should attempt to walk down the track at constant low speed. Each timekeeper will start his/her stopwatch at the signal of the lab instructor, and stop his/her stopwatch when the moving student passes his/her own position. Record the time it took to pass each position[1].

Repeat the experiment for a student who attempts to walk down the track at a constant higher speed.

Have one student tow a skateboarder with a constant force by pulling a spring so that it always has the same length. Marks on the spring tube indicate two different forces. Timekeepers should be beside the marks along the path. All should start their timers just as the motion starts, and each should stop his/her timer just as the skateboarder passes. Repeat for a different force, for a different mass skateboarder.

On the same graph plot position vs time for the walkers and for the skateboarder. [D11] Are the velocities constant? [D12] If so, what are their values? [D13] Write a paragraph justifying your answers and explaining what factors influence the results and how.

Portions of this exercise were adapted from the *Operation Physics* materials.

[1] Back in the laboratory you will place your data in a table on the chalkboard so that everyone can use them.