

EQUIPMENT BUILD PLAN

MOTION & FORCES

Bar Pendulum vs. Simple Pendulum

A meterstick hangs on a thin rod next to a string pendulum. A series of three comparisons shows that a bar does not swing like a simple pendulum of the same length, that it matches a simple pendulum two-thirds as long, and that it keeps that same period when re-hung from a hole two-thirds of the way down. The setup takes minutes and leads to rich discussion of how mass distribution affects motion.

Written from Bruce's original workshop handout. Bruce's final review of this plan is in progress.

What it shows

A swinging meterstick keeps the same beat whether it hangs from its end or from a point a third of the way down. Why?

Key ideas: pendulum period, physical pendulum, center of mass, moment of inertia, torque, center of oscillation

Safety (Everyday care). Keep the support rod above or below face height so nobody walks into the end that sticks out, and clamp the stands firmly so they cannot tip.

CONSTRUCTION



DIFFICULTY	BUILD TIME
Beginner	30 minutes
COST	SAFETY
About \$10	Everyday care
GOOD FOR	
Teachers	

Build it

Materials

- ☐ **Meterstick (wood or metal) or a uniform bar** · 1
This is the bar pendulum
- ☐ **Vertical support rods** · 2
Clamped to a table about 1/2 to 3/4 m apart
- ☐ **Horizontal cross bar** · 1
Clamped near the top of the supports, sticking out past the table edge
- ☐ **Thin stiff rod, about 1/8 in diameter** · 1
The pivot; a few inches stick out past the cross bar
- ☐ **Masking tape or rubber bands** · As needed
To fasten the pivot rod to the cross bar
- ☐ **String and a small heavy bob** · About 1.2 m of string
For the simple pendulum

Tools

Drill with a small bit (to suit the pivot rod)

Table clamps

Meterstick or tape measure

Stopwatch

1

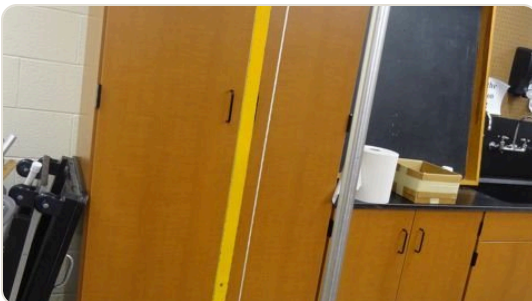
Drill the bar

Drill a small hole for the pivot rod near one end of the meterstick, and a second hole two-thirds of the way along the stick, measured from the far end (the 1/3 point from the first end).

2

Clamp the supports

Clamp two vertical rods to a table about 1/2 to 3/4 m apart, then clamp a horizontal cross bar near their tops so one end extends past the table edge, giving a clear swinging space.



3

Add the pivot rod

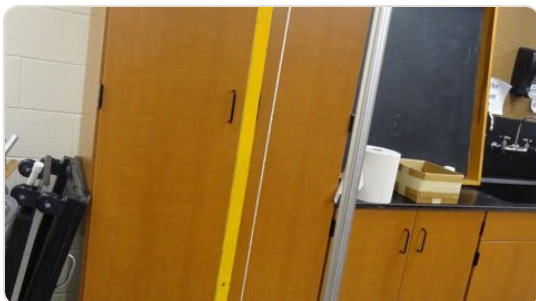
Tape or rubber-band the thin 1/8 in rod to the end of the cross bar so a few inches stick out. Both pendulums will hang from this rod.



4

Comparison 1: same length

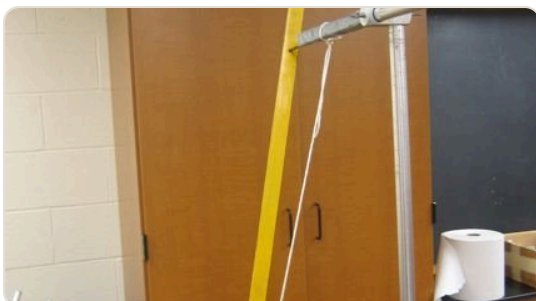
Hang the meterstick from its end hole and hang a simple pendulum whose length (pivot to center of the bob) is also 1 m. Pull both back a short distance, release together, and watch the bar pull ahead.



5

Comparison 2: matching period

Challenge students to find the string length that keeps time with the bar. Shorten the string to about 66.7 cm (two-thirds of the bar) and release them together again.



6

Comparison 3: re-hang the bar

Move the meterstick to its second hole, so one-third of it is above the pivot and two-thirds below. Keep the 66.7 cm simple pendulum and compare again: they still swing together.

How it works

For small swings, a simple pendulum's period is $T = 2\pi \sqrt{L/g}$. A 1 m pendulum has a period of about 2.0 s.

A bar's mass is spread along its whole length. The parts near the pivot act like short pendulums that want to swing faster, and they hurry the whole bar along. Using $T = 2\pi \sqrt{I/(mgd)}$, where I is the moment of inertia about the pivot and d is the distance from the pivot to the center of mass, a 1 m bar hung from its end has a period of about 1.64 s, the same as a simple pendulum $2/3$ m long. That length is called the equivalent length, and the point $2/3$ m below the pivot is the center of oscillation.

The surprise in comparison 3 is a general rule discovered by Christiaan Huygens: the pivot and the center of oscillation can trade places without changing the period. Hung from the $1/3$ point, the bar has its center of mass only $1/6$ m below the pivot, so gravity's twist (torque) is much smaller, but its moment of inertia is also smaller, and the two changes balance exactly. Any bar has many such matching pairs of pivot points.

GO FURTHER

Variations

- Use an iron bar or a metal meterstick instead of wood for a steadier swing.
- Hang the bar on a nail or knitting needle if you do not have lab stands.

IF IT DOESN'T WORK

Troubleshooting

IF THIS HAPPENS

The periods drift apart after a few swings

Using it

- After each comparison, stop and ask students to predict and then explain the result before revealing the next step.
- Time 10 swings of each pendulum and compare with the calculated periods (2.0 s and 1.64 s).
- Try other pivot points on the bar and plot period against pivot position; the period is longest near the center and has a minimum near 29 cm from the center.
- Follow up with simple-pendulum investigations: does the bob's mass matter? does the length? does the size of the swing? (Galileo is said to have timed a swinging chandelier with his pulse.)
- Contrast with a mass on a spring, whose period does change with mass.

TRY THIS

Keep the swings small (a short pull-back) and measure the string length to the center of the bob.

IF THIS HAPPENS

The pivot hole is not exactly at the end

TRY THIS

That shifts the numbers slightly. With the top hole 1 cm in from the end, the matching simple pendulum is about 66 cm and the second hole should be at about the 67 cm mark.

IF THIS HAPPENS

The bar rubs or wobbles on the rod

TRY THIS

Make the hole just slightly larger than the pivot rod and keep the bar vertical.