UNIVERSAL JOINT

OBJECTIVE:

You will understand and demonstrate how a universal joint transmits power and movement between two shafts.

INTRODUCTION:

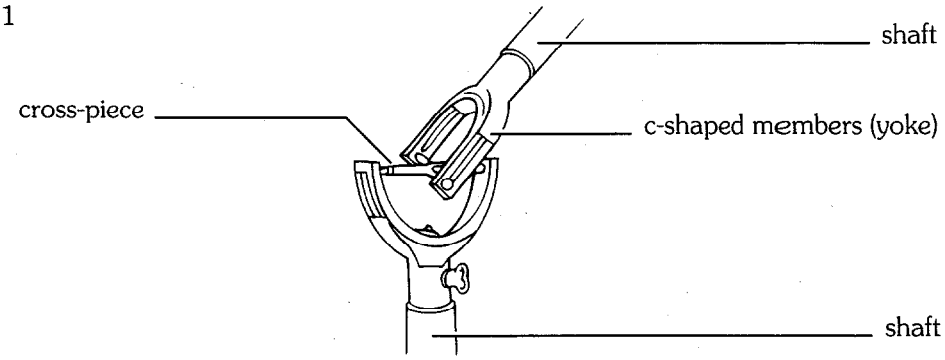
A universal joint is a device for transmitting power between two shafts at angles to one another. Normally, power or motion can be transmitted only in one direction. With the universal joint, it can be transmitted in all directions.

In 1676 English physicist Robert Hooke (1635–1703) developed the first "universal joynt," which was used to manipulate an astronomical device that enabled the viewer to observe the sun without receiving eye damage. The joint consisted of a C-shaped yoke on the end of each shaft, connected by a cross-piece pivoted to the ends of each C (see figure 1). Although Hooke suggested that it might be useful for various purposes, his invention excited little interest at the time. There was no demand before the nineteenth-century transportation revolution for a joint that could transmit motion in all directions.

With the development of machines driven by steam, diesel, and gasoline, however, the need for such a device became paramount. In an automobile with a suspension system, for example, a rotating shaft not only needs to engage with another shaft at an angle, but this angle will change when the car's suspension causes the drive axle to move up and down.

Universal joints are now used in many machines, from the simple spark plug wrench to sophisticated instruments and controls. Its primary use is in the drive system of automobiles.

Figure 1



TIME NEEDED:

1 hour

MATERIALS:

Note: You will need a partner for this investigation.

- 1-in., 4-in., and 8-in. lengths of 15mm-diameter wood dowel
- woodworking vice
- wood glue
- hammer
- 4 wood nails, 1 1/2 in. long
- 1 in. x 3 in. piece of heavy cardboard
- 2 pieces of medium-weight cardboard, 1 1/2 in. x 1/2 in.
- 2 wooden blocks, 3 in. x 2 in. x 1/2 in.
- wooden block 6 in. x 4 in. x 1/2 in.
- drill (electric or battery operated)
- 1/2-in. (15mm) drill bit
- protractor
- the following parts from a metal or plastic construction kit (e.g., Meccano®):
  - 5 1/2 in. x 2 1/2 in. baseplate
  - 2 5-in. uprights
  - 2 nuts and bolts
  - 3-in. rod
- 2 u-nails (from a hardware store)
- ruler
- paper
- pen

Note: If using an electric drill, you will need a source of electricity—e.g., a wall outlet.

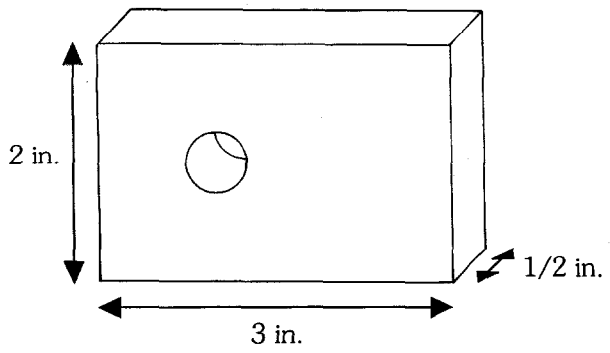
Safety Precautions

Adult supervision required. Please read and copy the safety precautions at the beginning of this book. Electricity can cause dangerous shocks. Be careful when using the drill.

PROCEDURE:

1. In each of the two smaller wooden blocks, drill a hole slightly larger than 1/2 in. diameter and with its center 1 in. from one end of the block (see figure 2).

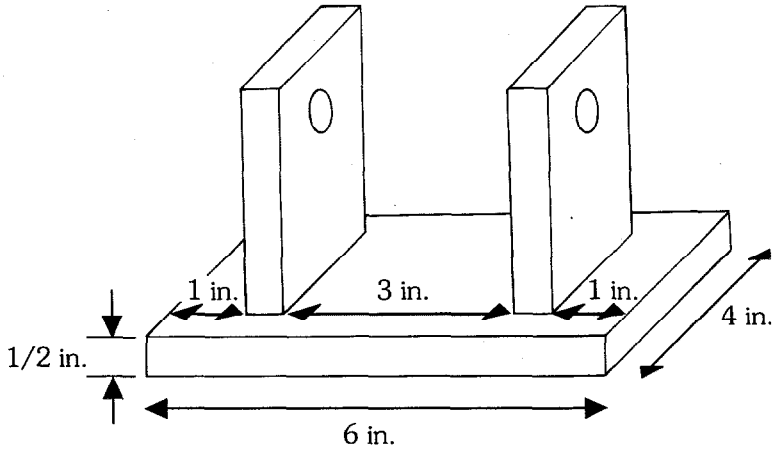
Figure 2



2. Hold the 8-in. length of wood dowel upright in a vice and hammer a u-nail into one end until a semicircle of metal is left standing out. Repeat this procedure with the 4-in. length of wood dowel, but first ensure that the two u-nails are hooked together, so that on completion the two lengths of wood dowel (the shafts) are connected by the u-nails.

3. Glue and nail the two smaller blocks to the larger wooden block (the base), each 1 in. from either end of the base, centered between the two sides (see figure 3). The smaller blocks should be upright and parallel to one another.

Figure 3

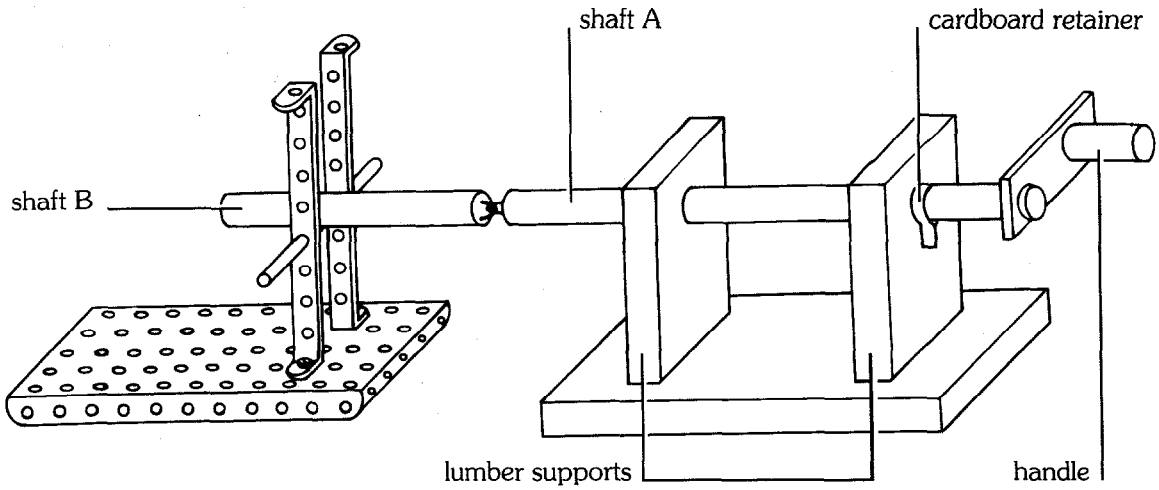


4. Pass the 8-in. length of wood dowel through the holes in the upright blocks. Fold a piece of medium-weight cardboard over the dowel next to where the dowel enters a hole. Secure the dowel in place by gluing the two ends of each piece of cardboard together; these act as retainers.

5. Glue one flat end of the 1-in. length of wood dowel to the piece of thick cardboard, near a short edge. Glue the other edge, and other side, of the cardboard to the end of the 8-in. dowel (shaft A) that is not connected to the 4-in. dowel (see figure 4). This is the handle.

6. Assemble the Meccano® support as shown in figure 4. The 4-in. dowel (shaft B) should rest on the Meccano® rod. Arrange it so that the rod can be positioned to raise shaft B at angles of 5°, 10°, 15°, and so on, above the horizontal.

Figure 4



7. With the two shafts arranged horizontally, turn the handle and check that the shafts can rotate easily. Turn the handle slowly, and have your partner observe what happens to the linkage as the handle is turned. Note how easy or difficult it is to turn the handle. Is this the same at all points as you turn the handle? Does the speed at which the joint turns vary at different parts of the turning cycle? Record your observations on paper.

8. Raise the rod so that shaft B is inclined at an angle of 5°. Turn the handle slowly, and have your partner observe what happens to the linkage as the handle is turned. Make the same observations as in step 7, and record your observations on paper.

9. Repeat step 8 at 5° intervals until you reach 40° above the horizontal. Record any observations for each angle of elevation.

ANALYSIS:

1. As the angle of elevation increased, what did you notice about the ease of turning and about movement at the linkage point between shafts A and B?

2. At what angle of elevation did the linkage seize up?

3. What do your answers to 1 and 2 tell you about the likely effectiveness of using a conventional universal joint in transmitting power from one shaft to the other?

4. Look at figure 1, showing a conventional universal joint. How does the linkage you used differ from this?

5. Do some research. Front-wheel-drive cars use a form of universal joint—called a constant velocity joint—that is more sophisticated than the conventional type. Why is this?

OUR FINDINGS:

Click on above link to see what we found.

SPECIAL SAFETY NOTE TO INVESTIGATORS

Each invention includes any special safety precautions that are relevant to that particular project. These do not include all of the basic safety precautions that are necessary whenever you are working on a scientific investigation. For this reason, it is absolutely necessary that you read, copy, and remain mindful of the General Safety Precautions that follow this note.

Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly when you are constructing or demonstrating a model invention. Things can spill, break, even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following basic safety guidelines the *entire* time you are carrying out the project, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual projects. We made this choice for one reason: We want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical to your safety.

One further note: The book assumes that you will read the safety precautions that follow, as well as those in the box within each project you are preparing to perform, and that you will *remember* them. Except in rare instances, these precautions will not be repeated in the procedure itself. It is up to you to use your good judgment and pay attention when performing potentially dangerous parts of the procedure. Just because the book does not 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, wait to perform it until you find out for sure that it is safe.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking unnecessary risks can be avoided by practicing safety procedures and being alert while carrying out these projects. Be sure to check the individual projects in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone.

PREPARING:
—Clear all surfaces before beginning projects
—Read the instructions before you start
—Know the hazards of the procedures and anticipate dangers

PROTECTING YOURSELF:
—Follow the directions step-by-step; do only one project at a time
—Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eye wash, and first-aid kit
—Make sure there is adequate ventilation
—Do not horseplay
—Wear an apron and goggles
—Do not wear contact lenses, open shoes, loose clothing, or loose hair
—Keep floor and work space neat, clean, and dry
—Clean up spills immediately
—Never eat, drink, or smoke in laboratory or work space
—Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult

USING EQUIPMENT WITH CARE:
—Set up apparatus far from the edge of the desk or bench
—Use knives and other sharp or pointed instruments with caution
—Pull plugs, not cords, when removing electrical plugs
—Clean glassware before and after use
—Check glassware for scratches, cracks, and sharp edges
—Clean up broken glassware immediately
—Do not touch metal conductors
—Use only low voltage and current materials such as lantern batteries
—Be careful when using stepstools, chairs, and ladders
—Never look directly at the sun with your observation devices

USING CHEMICALS:
—Never taste or inhale chemicals
—Label all bottles and apparatus containing chemicals
—Read 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 SUBSTANCES:
—Use goggles, apron, and gloves when boiling water
—Keep your face away from test tubes and beakers
—Never leave 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 fire extinguisher on hand

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
—Clean up all residue and put in proper containers for disposal
—Dispose of all chemicals according to all local, state, and federal laws

BE SAFETY CONSCIOUS AT ALL TIMES