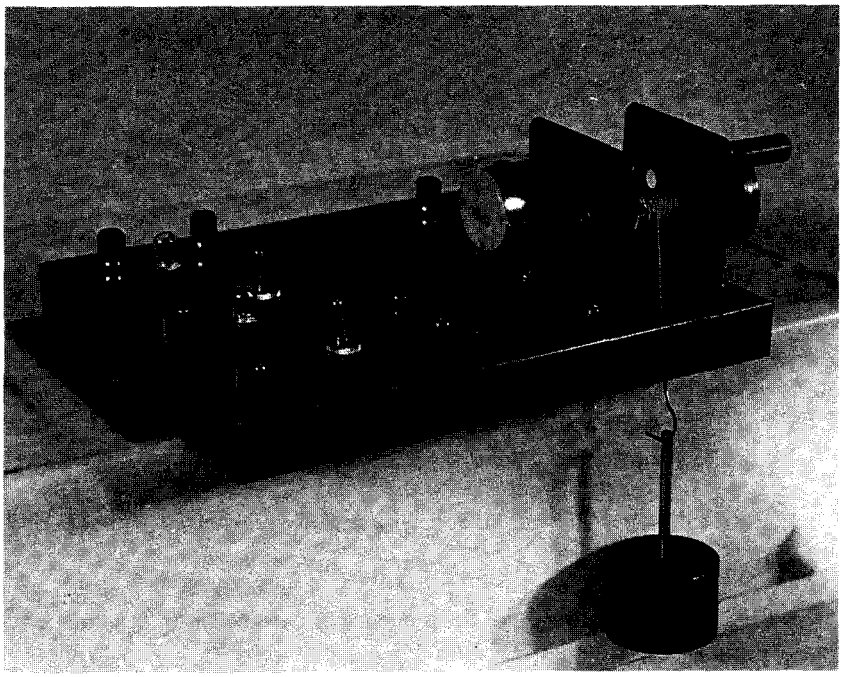
ENERGY INTERCONVERSION KIT



The Energy Interconversion Kit has been designed to demonstrate the interconversion of gravitational potential energy and electrical energy.

It consists of an electric motor connected to a winch that raises a fixed mass on the end of a string. The motor can be used to drive the winch, or the falling mass used to drive the motor as a generator. Two small globes are used to demonstrate the presence of an electric current.

The kit can vary in construction. In some models a system of gears is used to connect the winch and motor, instead of a belt and pulley.

SETTING UP AND USING THE ENERGY INTERCONVERSION KIT

It is worth checking the following items before an experiment is set up.

- ensure that the electrical connections are secure and make sure the mass is able to fall freely on to the floor
- trace the circuitry on the underside of the board to note which terminals are connected to the motor, lamps, etc. *NOTE: In some models there is a set of disconnected terminals labelled INPUT which cannot be used*
- ensure the bulbs are not blown
- replace the drive belt if it is worn
- tighten the spindle on to the shaft to avoid slipping
- check leads

Extra equipment required for the suggested learning experiences includes:

- electrical leads, including banana plugs
- a voltmeter (0-10V) or multimeter
- a meter rule
- a g-clamp to fasten the board to the desk firmly
- batteries for battery holder or power pack
- a milliammeter (0-500 scale)
- a stopwatch

HANDY HINTS

- Reverse the connections on both the voltmeter and milliammeter when switching from using gravitational potential energy to using electrical energy as the electrical current will be flowing in the opposite direction.
- Be careful to keep the banana plug connectors well away from the metal board so that there is no possibility of a short circuit.
- Wind the cord uniformly on the spindle to minimise energy loss.
- If the power pack is used as a source of electrical energy, try the "B" setting (3 volts).

SUGGESTION FOR USE IN THE CLASSROOM:

This piece of equipment is recommended to be used apart of a series of workstations based on mechanical interactions. With written instructions it is relatively easy for students to use as the underlying concepts are demonstrated quite concretely and the calculations are not overly complicated.

SUGGESTED LEARNING EXPERIENCES

TOPIC: Energy

1. Determining an energy conversion chain.

Demonstrate the interconversion of different types of energy beginning with stored chemical energy in the battery, progressing to gravitational potential energy in the raised mass on the string.

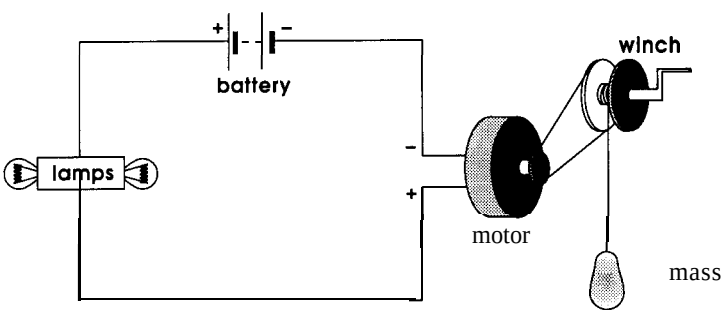


figure 1

To do this:

- Connect one of the 3v battery leads (or the 'B' setting of the power pack) to the input terminal of the motor as shown in figure 1.
- Turn on both switches for the bulbs.
- Attach a mass and carrier to the end of the string so that it is just resting on the floor. Connect the other battery lead and observe the motor pulling the mass up to the bench. Disconnect the battery when the mass reaches the bench.
- Watch as the mass then drives the motor as a generator in the opposite direction, creating an electric current which lights the globes.
- Experiment using a larger mass (masses over 500g are recommended). Ask the students to predict the outcome.
- Repeat the experiment using just one globe and discuss the results.
- Students should produce their answer in the form of a flow chart, indicating in which part of the device each transformation takes place and the possible pathways in which energy is lost.

2. Measure the electrical energy that can be produced by a falling mass.

This experience enables students to measure the amount of electrical energy generated from a known amount of gravitational potential energy and to determine the loss of energy in the process. ***To do this:***

- Connect the circuit as shown in figure 2, being careful to connect the meters so they record a positive deflection when the mass is falling to the ground.
- Wind the string carefully on to the winch and attach the mass and carrier to it.
- Support the mass and release when ready.
- With a meter rule, measure the distance travelled. Be careful not to include the height of the mass.

- Measure the mass of the falling object including the supporting mass carrier.
- Using $g=9.8\ ms^{-2}$, ask the students to calculate the stored energy in the falling mass from the equation

PE = mgh

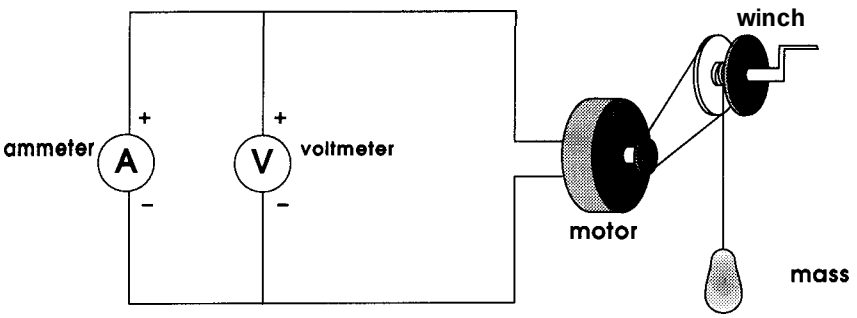


figure 2

- Take several readings of the time (seconds) taken for the mass to hit the floor.
- At the same time take readings of the voltage (volts) and current (amps) produced by the motor acting as a generator.
- Using the following equation, ask the students to calculate the electrical energy produced by the generator.

$$\text{WORK} = E_{Electric} = V\ I.t$$

- Compare the two values and determine the amount of energy 'lost' in the transformation. To reinforce the concept of energy conservation discuss where the 'lost' energy has gone (heat, sound).
- Encourage students to estimate their errors in taking measurements and in their calculated results. How does this affect their calculation of the energy lost in the conversion?
- Vary the mass of the object and compare the percentage energy loss in each case.

3. Measure the gravitational potential energy that can be produced by an electric motor.

This experience enables students to measure the gravitational potential energy converted from a known amount of electrical energy and hence to find the efficiency of the motor. ***To do this:***

- Connect the circuit as shown in figure 3 being careful to match the positive terminals of the meters with the positive terminal of the battery (or power pack).
- Position the mass and carrier on the floor immediately below the winch with the string taut.
- Use the device as a motor to raise a fixed load.
- Measure the quantities, as in the previous experiment, to determine the electrical potential energy used and the gravitational potential energy produced in the transformation.
- Calculate the efficiency of the motor by dividing its input energy (VIt) by its output energy (mgh) and multiplying by 100 to give a percentage.

$$\text{Efficiency} = \frac{VIt \times 100}{mgh}$$

- Vary the mass and compare the results. Does the motor have a standard efficiency rating?

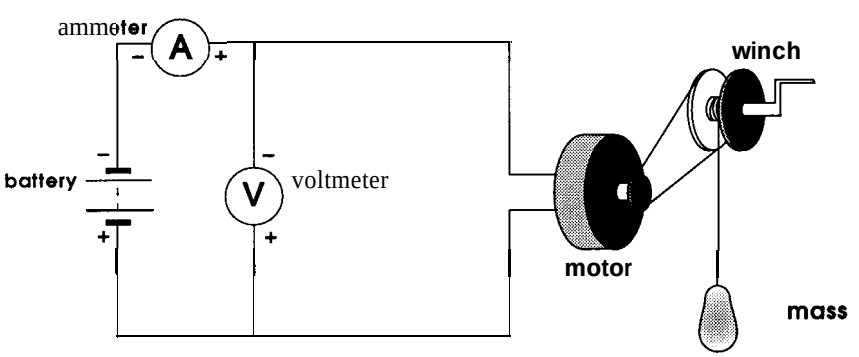


figure 3