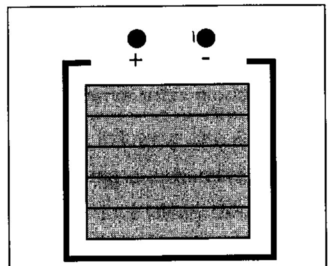
# Investigating the solar module - are the current and voltage outputs fixed?

**Apparatus required:**
- Solar module
- Load measurement box
- Connecting leads

**Additional components:**
- Lamp 100 – 150 Watt

**Safety: Please follow the operating instructions.**
**The solar module becomes hot in use.**
**A full risk assessment must be carried out before beginning this experiment.**

## Introduction



Solar module

A solar cell is a specially designed semiconductor diode which generates an e.m.f. when exposed to light. It can, therefore, be used as a low voltage D.C. power supply, but only up to a limit. A solar module is a number of solar cells connected in series so that the total e.m.f. obtained is the sum of the individual e.m.f.s. However the current obtained is limited by the internal resistance of each solar cell.

The behaviour of a solar module can be seen in its characteristic curve. This plots the current through the load resistor against the e.m.f. (voltage) delivered by the cell while the light intensity is kept constant. This curve will show, quite clearly, that there is, in fact, a particular point where the solar module can deliver maximum power for a given level of light intensity.

## Objective

To investigate the behaviour of a solar module when it is driving a current through increasing load resistors and to find the maximum power it can deliver at constant light intensity.

## Preparatory work

*Answer these questions before beginning any experimental work.*

1. Devise and draw a circuit which allows you to measure the e.m.f. generated by the solar cell when it drives a current through a range of load resistors. .
2. Outline what you will do to obtain appropriate data.
3. Explain what is meant by a characteristic curve.

## Procedure

- Construct your circuit and check that the apparatus gives readings over a suitable range.
- Vary the value of the load resistor and investigate how the e.m.f. and current vary as the value of the load resistor is changed. Ensure that the light intensity is kept constant throughout the investigation.

**Hint: Wait until the solar cell has reached a stable temperature before beginning the experiment.**

## Product

1. Explain the experimental technique used to obtain the data.
2. Devise and complete a suitable results table to record your data, either on paper or on a computer spreadsheet.
3. Plot the characteristic curve for the solar module.
4. Comment on the shape of the curve.
5. Re-draft the results and plot power against voltage and from this curve identify the Maximum Power Point of the solar module.
6. Comment on any problems you encountered during the experiment, any precautions taken to ensure accuracy and any changes you made to your original plan.
7. Finally evaluate the experimental technique you used and suggest any further improvements for the experiment.

## Experiment variations

Determine the influence of the light intensity on the power of the solar module. Record two further characteristic curves, changing the distance between the lamp and the solar module (to e.g. 20 cm and 40 cm).

At a distance of 20 cm the solar module must only be illuminated for the duration of the experiment.
Draw graphs plotting P against V and compare them with the PV diagram at a lamp distance of 30 cm.

## Question

- What is the significance of the Maximum Power Point of the solar module? Hint - if you were choosing a solar cell to operate a device, how would you take account of its maximum power point and why?

## Extension work

Research what materials a solar cell is made of and how a solar cell generates an e.m.f. when light falls on it.
(further information is available in the 'Research Notes' book).

# Investigating the solar module – is it really a diode?

**Apparatus required:**

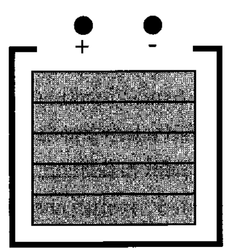
- Solar module
- Load measurement box
- Connecting leads

**Additional components:**

- Black cardboard
- Power-supply unit

**Safety: Please follow the operating instructions.**
**A full risk assessment must be carried out before beginning any experiment.**

## Introduction




Solar module

A solar cell will not produce an e.m.f. itself unless it is irradiated. A power supply can make a current flow through a non-irradiated solar cell and this current will vary as the applied e.m.f. is changed. The characteristic curve, a plot of I against V, of the solar cell will show whether it is acting as a diode when not irradiated.

## Objectives

To investigate the behaviour of a solar module when it is not irradiated and to determine whether it acts as a diode.

## Preparatory work

*Answer these questions before you begin the experimental work.*

1. Explain the meaning of the terms 'forward bias' and 'reverse bias' when applied to a diode.
2. Devise and draw a circuit diagram which will allow you to vary the e.m.f. supplied to a solar cell from a D.C. power supply and measure the current which flows through it when it is forward biased.
3. Outline what you plan to do to obtain appropriate data.

## Procedure

- Construct your circuit and check that the apparatus gives readings over a suitable range – keeping the applied voltage below 3.0 volts.
- Vary the applied e.m.f. and monitor the changes in current flow. Ensure that the solar cell is not irradiated throughout the experiment.

**N.B. the applied voltage must be kept below 3.5 V in forward bias.**

- Turn the solar module to 'reverse bias' and monitor the current for various values of applied e.m.f.

**N.B. the applied voltage must be kept below 3 V in reverse bias.**

## Product

1. Draw the circuit diagram and explain the experimental technique used to investigate the behaviour of the solar cell.
2. Devise a suitable results table to record your data, either on paper or on a computer spreadsheet.
3. Plot the characteristic curve for the non–irradiated solar module in forward bias and in reverse bias.
4. Comment on the shape of the curves.
5. Comment on any problems you encountered during the experiment, any precautions taken to ensure accuracy and any changes you made to your original plan.
6. Finally evaluate the experimental technique you used and suggest any further improvements for the experiment.

## Questions

- A semiconductor diode is a 'p-n junction'. Explain what 'p' and 'n' signify in this context and what happens when a p-n junction is created.
- For solar cells connected in series a defective or shaded cell has the same effect as a resistor and may even overheat and be destroyed. Explain how a 'by-pass diode' connected in parallel with the cell will overcome this problem.