Solar Panel Exercises

1. **What variations are there in the Electrical power generated with changes of**
    a) **Panel angle**
    b) **Panel direction**
    c) **Shade?**
2. **What is the power conversion efficiency of the solar panel?**
3. **How do these variations affect the speed / load of the train or pump?**
4. **For more advanced students the I/V characteristics of the panel could be demonstrated**

Equipment

Solar panel rig, recording sheet (p2), solar power meter, train set, quarter & circular graphs to illustrate results (p4,5)

1. With a load connected, point the panel towards the sun and adjust the load to give maximum power.
   Note that power is the product of voltage (***V***) and current (***I***), i.e. ***P*** (Watts) = ***V*** (Volts) x ***I*** (Amps)

   a) Vary the **angle of the panel** from 0 to 90 degrees to the horizontal.
   Using the table on page 2, record the readings on the panel meters.
   Comment on the results, particularly the variations around the 30 degree position, which is the angle used for the solar farm panels.
   Discuss why this is the chosen angle.

   b) Set the panel to 30 degrees.
   Change the direction of the panel by rotating horizontally (on the trolley) through 360 degrees, as indicated on a compass.
   Record the readings on the panel meters.
   Comment on the results, particularly the variations around the due South direction, which is the direction in which the solar farm panels are set.
   Discuss why this is the chosen direction.
   Note the time of day, set the panel to face the sun in its current position. Record the direction and comment on the result.

   c) Pass the cover across the front surface to shade the panel.
   Record the meter readings while doing this.
   Discuss the effect of shadow on the panel output.

2. Power Conversion Efficiency – this is the ratio of the electrical power delivered by the panel to the solar power received by it.
   - Point the panel directly at the sun and adjust the electrical load so that maximum power is indicated on the panel meters.
   - Switch on the solar power meter and press the '**W/B**' button until the display shows '**W/m^2**. Point the meter directly at the sun and measure and record the solar power, if the display shows '**OL'** press the **'R'** button to switch to a higher range.
   - Record the readings of the panel meters.
   - Using the area of the panel, which is 0.54 m^2 and the reading from the solar power meter, calculate the power received by the panel and hence the power conversion efficiency for it; this should be in the range 12 – 15%.

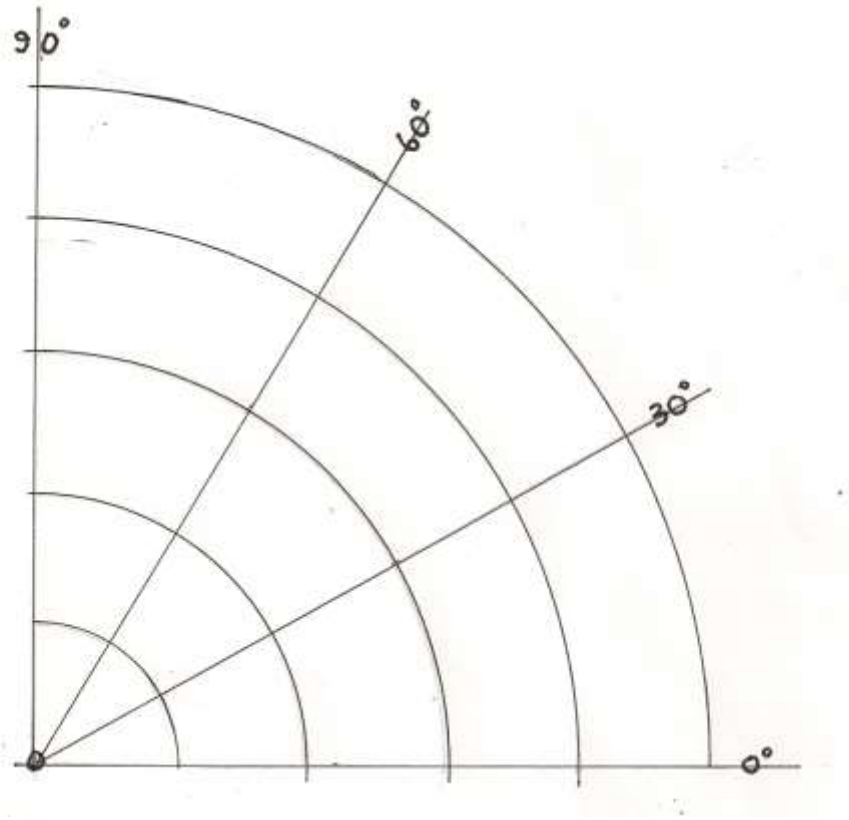
Recording Table for Solar Panel Meter Readings (ex 1 & 2)

1a) Angle of solar panel for example	Panel Voltage (V) Volts	Panel Current (I) Amps	Electrical power generated (Pe=VxI) Watts
0°			
20°			
30°			
60°			
90°			
1b) Compass direction of solar panel at and angle of 30°	**Panel Voltage (V) Volts**	**Panel Current (I) Amps**	**Electrical power generated (Pe=VxI) Watts**
North			
North East			
East			
South East			
South			
South West			
West			
North West			
Direction of sun now			
1c) Shading of panel	**Panel Voltage (V) Volts**	**Panel Current (I) Amps**	**Electrical power generated (Pe=VxI) Watts**
Zero			
c. 25%			
c. 50%			
c. 75%			
c.100%			

2. Solar power meter reading (Pm) Watts	Solar power received (Pr = 0.54xPm) Watts	Panel Voltage (V) Volts	Panel Current (I) Amps	Electrical Power Generated (Pe = VxI) Watts	Energy Conversion Efficiency (Pe/Pr x 100) %

Note that to drive a single Eurostar train at full speed (186 mph) would require the full output of 2 wind farms the size of that at Westmill operating in a strong wind or 2⅔ solar farms the size of that at Westmill operating in bright summer sunshine.

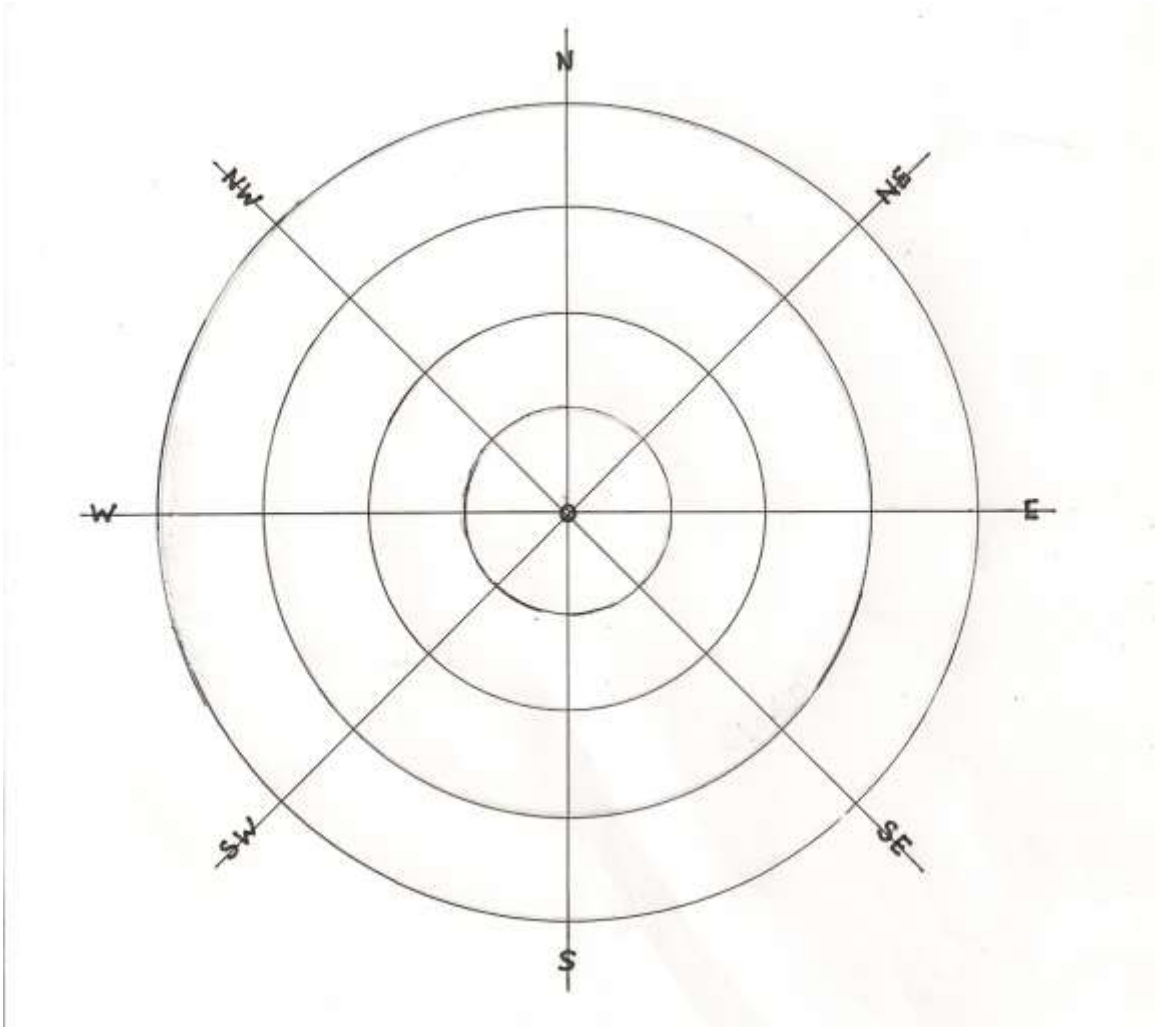
GRAPH TO SHOW SOLAR PANEL POWER VARIATIONS IN ELEVATION



Instructions

The circles represent increasing power levels from the centre and should be scaled in watts according to the maximum power measured during rotation of the panel in elevation from 0^0 to 90^0. Plot points on the graph corresponding to the power measured at each elevation setting. Join these points with a smooth line – this shows the polar variation of panel output in elevation.

GRAPH TO SHOW SOLAR PANEL POWER VARIATIONS IN AZIMUTH



Instructions

The circles represent increasing power levels from the centre and should be scaled in watts according to the maximum power measured during one complete horizontal rotation of the panel. Plot points on the graph corresponding to the power measured at each compass setting. Join these points with a smooth line – this shows the polar variation of panel output in azimuth.