

School: _____

Names: _____

Total Score: _____ Place: _____

Science Olympiad Physics Lab: Work, Energy and Power Lab Component (40 points)

Lab Component: Design and Construct a [student] Wind-Powered Apparatus to Raise a Mass to a predetermined height in order to maximize the power produced. Team will have 25 minutes from the beginning of the competition to build the device. Moderator will time performance and verify mass, time and height performance.

Equipment:

1. 1 pair scissors
2. 8 – 4”x 6” index cards
3. 1 - 9” x 3/16” diameter dowel
4. 1 – drinking straw
5. 1 – roll masking tape
6. 2 m string (considered 0.000 kg for calculations)
7. 2 – 1”x1”x1” wooden blocks (0.010kg)
8. 1 – small plastic Dixie cup (0.002 kg)

Quantity	Mass (kg)	Height (m)	Time (s)	Work (J)	Power (W)
Measured Value				-----	-----
Moderator init				-----	-----
Calculated Value	-----	-----	-----		
Pts Earned [correct calculation]	-----	-----	-----	__ / 5	__ / 5
Pts Earned [performance]	-----	-----	-----	__ / 10	__ / 20

Total Points: _____

Performance Table

Work (J)										
Work Points	1	2	3	4	5	6	7	8	9	10
Power (W)										
Power Points	2	4	6	8	10	12	14	16	18	20

Points this page _____

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Science Olympiad

Physics Lab: Work, Energy and Power

Knowledge Component (@ 3 pts / question = 60 points)

1. A power plant produces 500 MW of power. How much energy is produced in one second? _____ J

2. A power plant operates in four stages. The efficiency in the successive stages are: 80%, 40%, 12% and 65%. What is the overall efficiency of the power plant?

_____ %

3. A coal power plant with 30% efficiency burns 10 million kilograms of coal a day. (Take the heat of combustion of coal to be 30 MJ / kg.)

a) What is the power output of the plant? _____ W

b) At what rate is thermal energy being discarded by the plant? _____ W

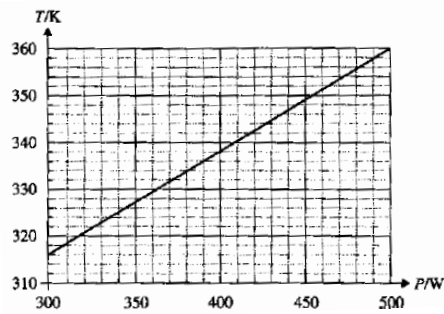
4. Sunlight of intensity 700 W / m^2 is captured with 70% efficiency by a solar panel, which then sends the captured energy into a house with 50% efficiency. If the house loses thermal energy through poor insulation at a rate of 3.0 kW, find the area of the solar panel needed in order to keep the temperature of the house constant.

_____ m^2

5. A solar heater is to warm 150 kg of water by 30K. The intensity of solar radiation is 6000 W / m^2 and the area of the panels is 4.0 m^2 . The specific heat capacity of the water is $4.2 \times 10^3 \text{ J / kg K}$. Estimate the time this will take, assuming a solar panel efficiency of 60%.

_____ sec

Points this page _____

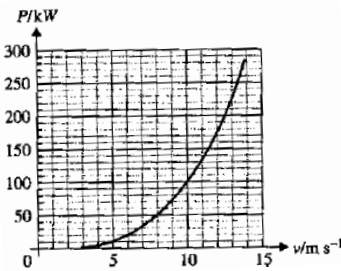


6. The above graph shows the variation with incident solar power P of the temperature of a solar panel used to heat water when thermal energy is extracted from the water at a rate of 320 W . The area of the panel is 2.0 m^2 and the intensity of the solar radiation incident on the panel is 400 W / m^2 . Calculate:

a. The power incident on the panel _____ W

b. The efficiency of the panel _____ %

c. The temperature of the water _____ K



7. The above graph shows the power curve of a wind turbine as a function of the wind speed. If the wind speed is 10 m/s , calculate the energy produced in the course of one year assuming that the wind blows at this speed for 1000 hours in the year. _____ J

8. The formula for wind power as a function of the air density, cross sectional area of the wind turbine blades and the wind velocity is given by $P = \frac{1}{2} \rho A v^3$

State the expected increase in the power extracted from the wind turbine when

a. the length of the blades is doubled: _____

b. the wind speed is doubled: _____

c. both the length of the blades and the wind speed are doubled: _____

d. State one reason why the actual increase in the extracted power will be less than your answers above _____

9. Air density 1.2 kg / m^3 and speed 8.0 m/s is incident on the blades of a wind turbine. The radius of the blades is 1.5 m . Immediately after passing through the blades, the wind speed is reduced to 3.0 m / s and the density of the air is 1.8 kg m^3 . Calculate the power extracted from the wind. _____W

10. Find the power developed when water in a waterfall with a flow rate of 500 L / s falls from a height of 40m . _____W

11. A force of 4.0 N is required to stretch a spring 0.2 m . The spring obeys Hooke's law. Find the energy stored in the spring when it is stretched to 0.8m . _____J

12. The potential difference between the Earth and the bottom of a thundercloud is 35 million Volts. The bottom of a line thunder clouds is 1500 m above the earth and the area of the cloud bottoms is 110 km^2 . Modeling this Earth-cloud system as a huge capacitor, calculate:

a. The capacitance of the Earth-cloud system. $\epsilon_0=8.85\text{e-}12 \text{ C}^2/\text{Nm}^2$ _____F

b. The charge stored in the "capacitor" _____C

c. The energy stored in the "capacitor" _____J