University of California at Santa Cruz,
Jack Baskin School of Engineering

EE-80J: Renewable Energy Sources

Flywheel Laboratory Pre Questionnaire

Oxana Pantchenko and Prof. Ali Shakouri

Student's name_____ Student ID_____

TO BE COMPLETED AND TURNED IN TO TA BEFORE STARTING THE EXPERIMENT

1. The power measured across a resistive load is 100W. Now, if we were to double in value the resistive load, while keeping voltage level the same, what would the measured power value be?
    a. 0 Watts
    b. 50 Watts
    c. 100 Watts
    d. 200 Watts
    e. 1000 Watts
2. On one day, the measure voltage level across a resistive load is V and generated power therefore is P. On the second day, the measured voltage is 2*V, what is the power level?
    a. ½ P
    b. P
    c. 2P
    d. 4P
3. Consider two objects of mass m and mass 2*m, both dropped at the same time from the second story building. Which statement is correct,
    a. The gravitational potential energy of both objects is the same
    b. The gravitational potential energy of heavier object is larger than of the lighter one.
    c. The gravitational potential energy of heavier object is smaller than of the lighter one.
4. Consider one object dropped from a second story building and then the same object dropped from four story building. Compare the gravitational potential energy,
    a. Gravitational potential energy is higher when object is dropped from the 4 story building
    b. Gravitational potential energy is higher when object is dropped from the 2 story building
    c. Gravitational potential energy the same in both cases
5. Circle the correct definition of efficiency,
    a. Efficiency = (energy in / energy out) *100%
    b. Efficiency = (energy out/ energy in) *100%
    c. Efficiency = 1 – energy in/energy out
    d. Efficiency = 1 – energy out/energy in

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Flywheel Laboratory Experiment

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Student's name_____ Student ID_____ Grade _____ / _____

ABSTRACT

In this experiment, students will obtain knowledge about gravitation potential energy, generated electrical energy and rotational kinetic energy. Students will study the storage of rotational kinetic energy of a flywheel attached to a generator. By dropping a mass, connected by a string to a generator a distance, students will be able to measure generated voltage and calculate the power that was generated by the mass.

INTRODUCTION

Many of the renewable resources that are examined in this class involve converting rotational energy into electrical energy. The rotational energy can be derived from wind, water falling, ocean waves, etc. Each one of these renewable resources is utilized by placing an impeller in a location susceptible to high wind or rushing water. The renewable energy causes impeller to rotate, which rotates a magnet surrounded by coil to generate an electrical current. In this lab, students will use the same kind of force that powers many types of hydroelectric power plants, gravity. The goal for this lab is students to gain understanding of rotational energy and its role as a renewable energy source.

LIST OF MATERIALS

- ET generator (1)
- Flywheel (1)
- Flywheel nut (1)
- Pulley (1)
- LED Plug (1)
- Resistor Plug (1)
- Thread
- LabView
- Alligator clips (2)
- Styrofoam cup (1)
- Packing peanuts (handful)

Figure 1 Supply box of materials. Make sure your box has all the listed components. If something is missing, inform your TA.

PROCEDURE

1. Use the rod clamp on the side of the ET-Generator to mount the generator to a rod stand.
2. Insert the LED plug into the jacks on the generator. (See Figure 2)
3. To attach the pulley, align the indent marks on the pulley with the indented portion of the black shaft on the generator; then slide the pulley onto the shaft. Fasten the nut tight over the screw to hold the pulley in place.
4. Fill the plastic bucket with packing peanuts half way full and place it underneath the hanging mass.
5. Cut a piece of string to tie to the hanging mass and pulley. The string should be approximately 2 feet long.
6. Tie a quadruple knot in the string and hook the knot in the slot on the pulley.
7. Attach the other end of the string to the hanging mass.
8. Wind the string up on the smallest pulley, such that the string falls out when the mass reaches the bottom of the plastic bucket.
9. Adjust the position of the hanging mass or the height of the generator so that the knot slips out just as the mass reaches the plastic bucket.
10. For demonstration: Insert the plug with the light into the banana jacks and watch the bulb light as you turn the generator. The red/green light diode shows that the generator produces an AC voltage.

Figure 2 Experimental Set-up. The thread is tied to the mass on one end and quadruple knotted at the other. The knotted end is placed in a notch that is in the pulley.

11. Find EE80J folder on your desktop. Open EE80J/Flywheel Lab. Locate two alligator wires from USB-6008 board to your set up.
12. Insert the plug with the 100 Ohm resistor into the banana jacks.
13. Connect the red alligator clip from the USB-6008 to the red jack on the ET-Generator.
14. Connect the black alligator clip from the USB-6008 to the black jack on the ET-Generator.
15. In LabView, click the start button. Let the mass fall and record the voltage.
16. In LabView, click the stop button and observe generated Voltage vs. Time plot. Plot it in the provided axis.

17. Make a Power vs. Time plot using following relation;
    Power = Voltage ^{2} / Resistance

18. Record the value of the generated electrical energy. Be sure to include units.

    Generated electrical energy = _____( )

19. Calculate the charge in gravitational potential energy, where,

$$PE = m * g * h = \_\_\_\_\_$$

20. Calculate the efficiency (percent of energy transferred), using equation,

    Efficiency = (energy generated / gravitation potential energy) x 100%

    Efficiency =_____

21. Remove the resistor plug.
22. Remove the clear, plastic pulley from the ET-Generator.
23. Measure the mass and radius of the flywheel. Ignore the small pulley.

    Mass=_____

    Radius=_____

Figure 3 Experimental Set-up with flywheel in place.

24. Slide the flywheel on to the black plastic shaft. Align the metal pin on the flywheel with the plastic key on the shaft. Secure with the knurled nut. See Figure 3.
25. Tie a loop of thread around the flywheel and to a mass.
26. Tie a quadruple knot in the string and hook the knot in the slot on the pulley.

27. Connect the red alligator clip from the USB-6008 to the red jack on the ET-Generator.
28. Connect the black alligator clip from the USB-6008 to the black jack on the ET-Generator.
29. In LabView, click the start button. Let the mass fall and record the voltage.
30. When the flywheel is spinning the fastest, what is the period at which the flywheel is rotating? Note: In order to find the period, locate the magnitude vs. frequency plot in LabView. Each spike represents frequency. The reciprocal of the highest frequency is the period when the flywheel spinning the fastest. Record your answer.

    Period = _____(sec)

31. Calculate the maximum rotational kinetic energy of the spinning flywheel. Use the equation,

$$KE_{rotation} = \frac{1}{2} I \omega^2$$

    where,

    I: rotational inertia of the disk
    ω: angular velocity or (2* π)/ period

    Also, use the equation,

$$I = \frac{1}{2} mR^2$$

    Where,

    m: mass (kg)

    R: radius (m)

32. Calculate the charge in gravitational potential energy, where,

$$PE = m * g * h = \_\_\_\_\_$$

33. Calculate the efficiency, where the percent of energy transferred to the flywheel is

    (KE rotation / PE) *100% = _____

34. Compare your answers in step 20 and step 33. Which system is more efficient?

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Flywheel Laboratory Post Questionnaire

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