Worksheet: Energy and power

Name: _____ Group name: _____

Today you will assemble a simple calorimeter and measure the energy deposited in a known amount of water (100 ml) from different energy sources. The calorimeter consists of the water in a Styrofoam cup, and a thermometer. Recall (from your prelab reading) that the amount of energy transferred to the water is $\Delta E = mC\Delta T$, where ΔT is the change in temperature, and the specific heat of water is: $C \approx 1 \frac{\text{cal}}{\text{g °C}}$.

1. Assemble a calorimeter: Pour 100 ml of water into the styrofoam cup. Stick your hand into the water and use your body heat to bring it up to about room temperature. Put the feeler of your thermometer into the cup and bend the wire such that it nicely holds the feeler in the water close but not touching the wall. Let the system *equlibrate* while gently stirring the water (we consider a system in equilibrium if the change in temperature is less than 0.2°C per 10 seconds)

   - Initial water temperature T_{init} = _____ ___
   - Initial thermal energy stored in water: E_{th} = _____ ____
   - Measure the temperature of the hot brass masses provided by the instructor (Hint: what are these masses in equilibrium with?): T_{brass} = _____ ____
   - Get a stopwatch and the cup cover ready. Gently drop a hot brass mass into the calorimeter, and don't let it touch the temperature feeler. Cover the cup. Record the temperature every 10 seconds until the temperature changes by less than 0.2°C per 10 seconds. Sketch the behaviour temperature vs. time in a graph:

t	***T***
0s	
10s	

- Take a straw and gently stir the water until the temperature again equilibrates.

  T_{final} = _____ ____

- Compute the thermal energy gained by the water: ΔE_{th} = _____ _____

- Take out the brass cube and feel the temperature of brass cube and the water. What happened? How much thermal energy did the cube lose? Why?

- Use your observation to compute the specific heat of **brass**.

  C_{brass} = _____ _____

2. Connect a resistor to the power supply using clip-leads and alligator clips. (Sometimes, you have to push the clip leads **hard** into the power supply until they don't wiggle anymore.) Do not turn on the power supply just yet. Immerse the resistor in the calorimeter and secure the leads with tape, cover the calorimeter, and then turn on the supply to ~14 V.

   - Record the voltage: V = _____ _____

   - Every 60 seconds, briefly open the cup, stir gently, close the cup, and record the temperature. After 5 minutes (300 seconds), switch off the power supply. Sketch the behavior on the right:

t	***T***
0s	
60s	
120s	
180s	
240s	
300s	

- Compute the current using Ohm's law: I = _____ _____
- Computer the electrical power: P = _____ _____
- Compute the electrical energy lost: $E_{\text{el,lost}}$ = _____ _____
- Compute total temperature difference: ΔT = _____ ____
- Compute the thermal energy gained: $E_{\text{th,gained}}$ = _____ ____
- Compare electrical energy lost with themal energy gained. Did this match with you expecations? If not, speculate about what causes the difference:

3. Drop the lead shot. An instructor will help you with the apparatus. Drop the shot **20 meters** (turn the tube upside-down 25 times):
   - Temperature change: ΔT = _____ ____
   - Potential energy lost by the lead: $E_{\text{pot,lost}}$ = _____ _____
   - How much thermal energy is gained by the lead? Use it to compute the specific heat of lead:

     C_{Pb} = _____ ____
   - Compare the specific heat of brass, lead and water. Which one would you use to store energy?

4. Ride the exercise bike: once you get going with all lights turned **off**, have a partner turn on one or more. What you experience is the effective power needed to produce 100 W or 200 W of useful power. The table below, developed for weight management, shows some estimates of the Calories (kcal) burned for various activities. Compare, e.g. cycling or rowing to running: as the power output doubles, does the Calorie rate always double?

Example: 140lb person walking 3mph (20min/mile pace) for 15 minutes = 0.07 x 64.6kg x 15 = 67 calories

Activity	**Power (per kg)** (kcal/kg/min)	**Activity**	**Power (per kg)** (kcal/kg/min)
Racquetball (recreational)	0.07	Cycling (10-12 mph)	0.10
Kayaking (leisure)	0.04	Cycling (19 mph)	0.21
Dancing (general)	0.08	Cycling stationary (50W)	0.05
Golf (walking + bag)	0.09	Cycling stationary (100W)	0.09
Running (12 min/mile)	0.12	Cycling stationary (200W)	0.18
Running (9 min/mile)	0.19	Calisthenics	0.08
Running (7 min/mile)	0.24	Circuit Training	0.14
Running (6 min/mile)	0.28	Weight Training (light)	0.05
Chopping Wood	0.09	Weight Training (hard)	0.10
Mowing Lawn	0.08	Rowing (50W)	0.06
Raking Leaves	0.07	Rowing (200W)	0.21
Weeding/Gardening	0.07	Stretching/Yoga	0.06
Sitting Activities	0.03	Aerobics (low impact)	0.09
Standing (very light)	0.04	Aerobics (high impact)	0.12
Walking (20 min/mile)	0.06	Volleyball (recreational)	0.05
Walking (15 min/mile)	0.08	Bathing/Dressing	0.04
Sweeping	0.05	Swimming (light)	0.10
Washing Car	0.07	Swimming (moderate)	0.14
House Cleaning	0.06	Cooking	0.04
Washing Dishes/Ironing	0.04	Carrying Groceries	0.07
Kissing	0.02		