# PAL Problem Set 21 for Phys 5A
## (Intro to Thermodynamics)

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**Always explain your answers and show your work.**

**Problem 1 -** Riding a normal (not electrical) bike at 15 km/h requires less metabolic energy than running at the same speed. Suggest reasons that may explain why this is the case.

**Problem 2 -** Two blocks of aluminum are at the same temperature. Block A has mass 1 kg and block B has mass of 2 kg.
   A. Which one has more thermal energy?
   B. If the blocks are placed in thermal contact, will the thermal energy of the blocks change? If so, how?

**Problem 3 -** Give a specific example for each of the following processes:
   A. $\Delta E_{th} < 0$ and $W = 0$
   B. $\Delta E_{th} > 0$ and $W = 0$
   C. $\Delta E_{th} > 0$ and $W \neq 0$ and $Q = 0$
   D. $\Delta E_{th} > 0$ and $W \neq 0$ and $Q \neq 0$

**Problem 4 -** Suppose you want to warm up 250-ml of room temperature 30 °C to 100 °C to make a cup of tea. You will need to use the fact that 4.2 J of energy is required to raise the temperature of 1.0 mL of coffee by 1.0 °C.
   A. How much energy will you need to use?
   B. Assume that your microwave oven uses 1100 Watts of electrical power when it is running, and that it takes 130 seconds to warm up your cup of water. What is the efficiency of your microwave oven?
   C. Use the efficiency you found in part B to find out for how long you would need to run the microwave to increase instead 400 ml of water from 30 °C to 90 °C
      The water will need to absorb the following amount of energy:

**Problem 5 -** Rank the processes below based on the amount of energy required to increase the temperature of 50 ml of liquid water from $T_i$ to $T_f$. It may be helpful to remember that 4.2 J of energy is required to raise the temperature of 1.0 mL of coffee by 1.0 °C.

**Problem 6 -** Rank the processes from problem 1 above based on the amount of thermal energy contained in 50 ml of liquid water at the final temperature $T_f$.

| Process | $T_i$ | $T_f$ |
|---------|-------|-------|
| 1 | 10 °C | 20 °C |
| 2 | 20 °C | 30 °C |
| 3 | 285 K | 295 K |
| 4 | 300 K | 310 K |
| 5 | 50 °F | 60 °F |
| 6 | 100 °F | 110 °F |