Lab #_____: Power Work-Out Lab Name: _____ Period:_____ Date: _____

Partner name (s): _____

Purpose:

1. To approximate how much work and power your body generates against gravity when climbing stairs and when performing a physical exercise of your choice.
2. To practice calculating work and power.

Theoretical:

*Define and explain the following concepts, using **equations** whenever appropriate.*

Work, Joule
Power, Watt
Energy

Materials:

scale metric ruler stairs stopwatch

Procedures:

1. Obtain your own weight using a scale. Weight should be expressed in newtons.
   (Do this step at home as part of the pre-lab questions)
   Convert pounds to newtons by multiplying pounds by 4.45(1 lb = 4.45 N). *Convert kilograms to newtons with F=mg.*

Part 1: Climbing stairs

2. Measure the height of one step on the stairs (in meters).
3. Count the number of steps you will be climbing—and multiply this by the height of a step to find the total height, in meters.

4. Walk up the stairs at a comfortable pace while your partner times you. Record the time as accurately as possible in **your own** Table 1. You only record and analyze data taken for your own trips upstairs.
5. Repeat step #4 twice more, measuring time for two more runs.
6. Switch roles with your partner and repeat steps #4 & #5.

7. Repeat steps 4 to 6, this time, run up the stairs as quickly and **safely** as possible. Record data in Table 1.

8. Calculate your power while walking and running upstairs. Record the data in Table 1. Show work for calculations.

Part 2: Your choice of physical exercise

9. Choose a physical exercise: either push-ups, vertical jumps, calf raises, or sit-ups. Write down the name of the physical exercise in Table 2. **(You will also record your exercise choice as part of a pre-lab question. For the pre-lab, you only need to write down information in steps #10 and #11 that is relevant to your choice of physical exercise.)**

10. Perform your exercise once, and have your partner help you measure the following information for your chosen exercise to compute the work against gravity done in one repetition. Record your data in Table 2.

If your exercise is …	**Then record these quantities:**	
	For the force (against gravity) **in your exercise, use:**	**For distance in your exercise, measure:**
Push-ups	your entire body weight	Change in height of your waist area during a push-up
Sit-ups	half of your body weight	Change in height of your chest area during a sit-up
Calf-raises	your entire body weight	Change in height of your heel during a calf raise
Vertical jumps	your entire body weight	Difference in maximum height you can reach while standing straight and while jumping

11. Multiply the two quantities you recorded in step #10 for your exercise, and find work for one repetition of your exercise.

W	**=**	**F**	**·**	**d**
$W_{\text{push-up}}$	=	(your entire body weight)	·	(Change in height of your waist area during push-up)
$W_{\text{sit-up}}$	=	(half of your body weight)	·	(Change in height of your chest area during sit-up)
$W_{\text{calf raise}}$	=	(your entire body weight)	·	(Change in height of your heel during calf raise)
$W_{\text{vertical jump}}$	=	(your entire body weight)	·	(Difference in height reachable while standing and while jumping)

12. Perform your choice of exercise for 5 repetitions as quickly and powerfully (and safely!!) as possible while your partner times you. Record the number of repetitions and time measured as accurately as possible in **your own** Table 2.
13. Repeat step #12 twice more, measuring time for two more trails.
14. Switch roles with your partner and repeat steps #12 & #13.

15. Calculate power and record the values in Table 2.

16. Pool your own data with other classmates' data in the following class to compare the power outputs of different muscle groups in the human body. Fill in the appropriate information in Table 3.

17. Answer analysis questions.

Pre-lab questions:

Answer these questions after the procedures section of your pre-lab. You do not need to copy the questions; just number them.

1. Measure and write down your own weight in *newtons*. Show calculations for conversions if needed.

2. What is the physical exercise that you have chosen to perform for part 2 of the lab activity?

3. Draw a free body diagram of yourself while you move up the stairs with a steady pace (constant velocity).

   Label all the forces. (Hint: Whenever you move with a constant velocity, think of *dynamic equilibrium*. What must happen to all the forces?)

4. In this lab, while we move up the stairs with a steady pace, our bodies spend energy to generate (you can pick multiple; record the letters for your responses in your pre-lab)
   a. Work against gravity
   b. Work against friction
   c. Work to change our own motion
   d. Heat

5. When we just begin to go up the stairs from a state of rest, our bodies spend energy to generate (you can pick multiple)
   a. Work against gravity
   b. Work against friction
   c. Work to change our own motion
   d. Heat

6. [*extra credit*] Why do you think that we can multiply the force and distance measurements listed in step 10 to approximate the work done in one repetition of the physical exercises? Do you agree with this way of determining the work in one repetition? Do you have a better suggestion?

Observations and Data:

Your weight (N): _____ (as determined in your pre-lab question #1)

Table 1: Climbing stairs

Height of one step (m): _____ Total Height of stairs (m):_____

	Walking Upstairs			Running Upstairs		
	Time (s)	**Work exerted climbing the stairs (J)**	**Power (W)**	**Time (s)**	**Work exerted climbing the stairs (J)**	**Power (W)**
Trial 1						
Trial 2						
Trial 3						
average						

(Show calculations on the back of this page for total height of stairs, work performed climbing the stairs, and power)

Table 2: Your choice of physical exercise

	My choice of physical exercise: _____		Force in this exercise: _____ N Distance in this exercise:_____ m	
	Work exerted in one repetition (J)	**Total work exerted in one trial of 5 repetitions. (J)**	**Time for one trial of 5 repetitions (s)**	**Power (W)**
Trial 1				
Trial 2				
Trial 3				
average				

(Show calculations on the back of this page for work in one repetition, total work in one trial, and power)

Table 3: Physical exercise power comparisons

Exercise	Push-ups	Sit-ups	Calf raises	High jumps	Mass Lifts
Muscle group(s) involved					
Class Average Power (W)					
Power ranking					

Questions and Analysis:

1. What is the difference between work and power?

_____

_____

_____

_____

2. Which one took more *work*, walking or running up the stairs? Which one took more *power*? Explain.

_____

_____

_____

3. If you had climbed the stairs very, very slowly, how would the work have been affected? How would the power output have been affected? Explain.

_____

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_____

4. Two people climbed to the roof of the same building. The old person walked up a gentle ramp. The young person climbed up a steep ladder. Which person did more work against gravity? Explain.

(*Circle one*: The young person The old person Neither) did more work against gravity

because _____

_____

5. For the three times that you **walked** up the stairs, did you use the same amount of power? If not, then did your power increase or decrease throughout the trials? Why do you think it happened?
What about when you **ran** up the stairs? Did you use the same power? Why?

When I walked up the stairs, _____

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_____

When I ran up the stairs, _____

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6. For the three trials of your chosen physical exercise, did you do the same amount of total work for each trial? Did you use the same amount of power? Why?

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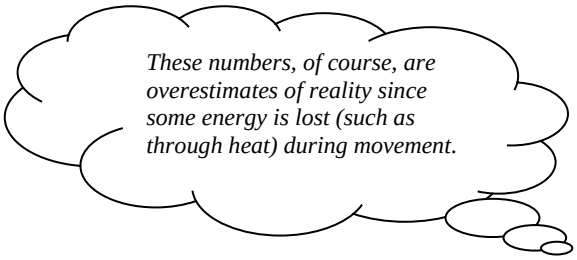
7. Compare your average power output during your physical exercise with the output of a horse by calculating your power output in horsepower. (1 horsepower = 746 W)

8. If your power could have been harnessed and the energy converted to electricity, then...
    a. The average power you generate while walking upstairs can keep _____ (how many) 100 W light bulbs on during that time.
    b. The average power you generate while running upstairs can keep _____ 100 W light bulbs on during that time.
    c. The average power you generate with your physical exercise can keep _____ 100 W light bulbs on during the time.

9. If you ate a 190-kilocalorie (190 kcal = 795000 Joules) granola bar, its energy would at most allow you to either go up _____ (how many) flights of stairs, or perform _____ repetitions of your selected physical exercise.
(*Show calculations below*)



10. When you compare the data we collected on the power outputs of different body parts on the human body, what body parts on the human body seem stronger, which ones seem weaker? Is this what you would expect? What do you compare when comparing strengths; do you look at work or power?

Conclusion (*Use the conclusion template: Remember to mention the purpose of the lab, your observations, your final results, the relevant theories and whether your results align with the theories. Also talk about how you would improve the lab.*

- *For your observations and results, refer to the **important** pieces of data in your data tables.*
- *For possible ways to improve the lab, one thing you can think about is how you would re-examine and possibly modify the ways to obtain work in each activity. If you answered pre-lab question 6, it would help you here.)*

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