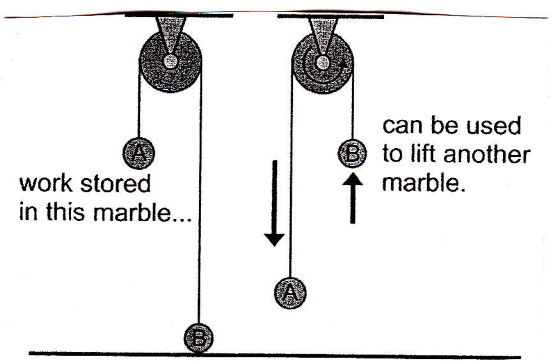
Work = Force × Distance (W=FD) and Power = Work / Time (P=W/t) : The Pulley Lab

Mechanical Advantage	Height (m)	String Length (m)	Input Force (N)	Output Force (N)	Work Done (output)	Work Done (Input)

1. As the mechanical advantage increases, what happens to the length of the string you pull to raise the block?

2. Use the following image to answer questions a, b, & c:



a. Marble A can be let back down to lift marble B. The work put into lifting marble A can be recovered and used to lift marble B. Study the diagram carefully. In order for marble A to lift marble B, what must be true about the weights of the two marbles?

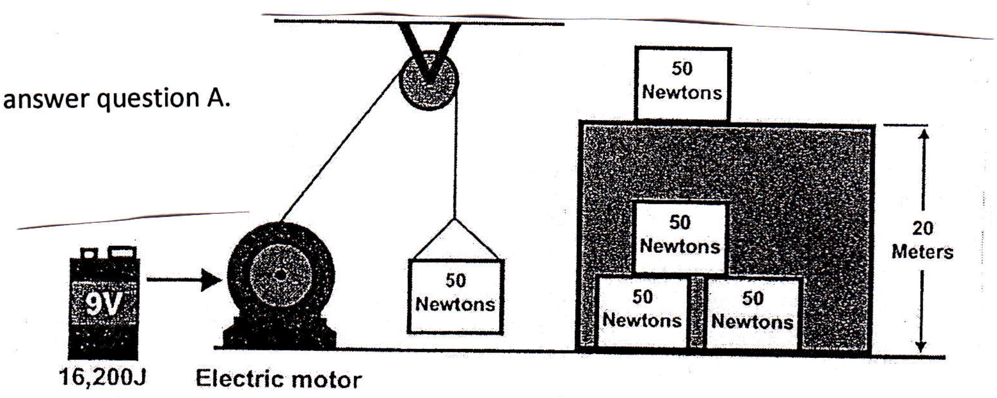
b. Using the arrows in the picture as a guide, describe the forces acting on marble A and marble B in terms of strength (magnitude) and direction.

c. The work that is stored when the first marble is lifted is a type of energy. Do you think the work being used to lift the second marble is the same or a different type of energy? Explain.

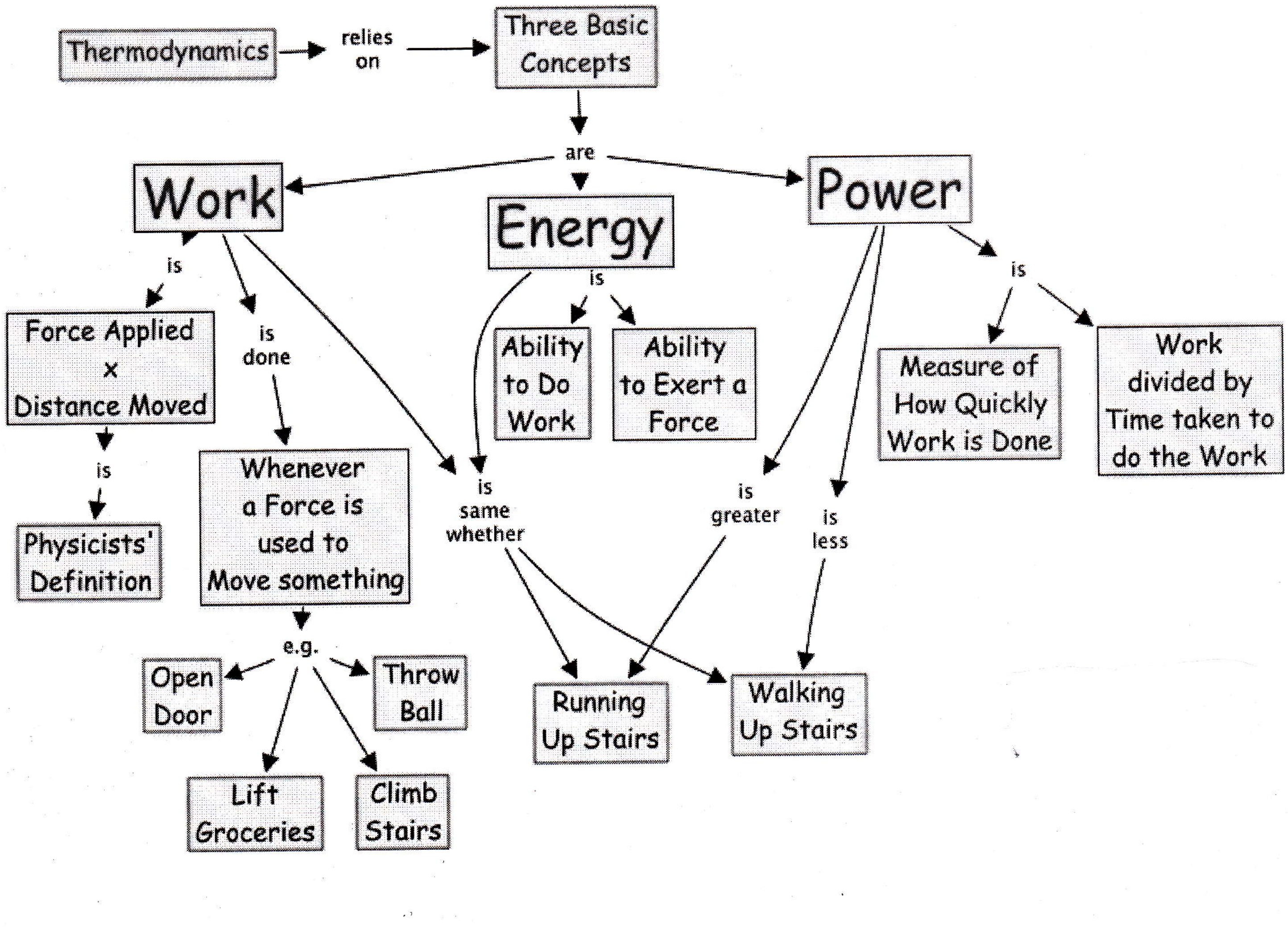
d. When 10 Joules of energy is used to lift the block on the ropes/pulleys the work is stored as energy. If the block is let back down the energy is recovered. You can confirm this by noticing that the string is pulling on you as you let the block fall back down. Try this with your rope and pulley system and explain your results in terms of work and energy.

3. The Work-Energy Theorem states that: an object that has energy has the ability to do work...meaning that the total amount of work that can be done is exactly equal to the energy available. This applies to everything in the universe. Can you think of one everyday example that demonstrates the Work-Energy Theorem?

4. Use the following diagram to answer question A.



a. One way to store energy is in a battery. One 9-Volt battery stores approximately 16,200 Joules of energy. Suppose you had a perfect electric motor and a pulley with no friction. How many 50 N boxes can you lift to a height of 20 meters using the energy sored in the battery? Show your work.



Work (in science) is defined as the amount of applied force multiplied by the distance through which the force is applied. A force acts upon an object to change its state of motion. To perform work according to this definition the direction of motion and the direction of force applied must be the same. Work is done when the direction of force applied and the direction of the distance traveled are parallel. The equation is: **Work (J) = Force (N) × Distance (m)**

Use the work equation provided to complete the following questions. Show all equations, work, and include units!

1. You pull a sled through the snow a distance of 500 meters with a force of 200 N. How much work is done?

2. A deflated hot air balloon weighs a total of 8000 N. Filled with hot air, the balloon rises to a height of 1000 m. How much work is accomplished by the hot air in the process of lifting the balloon?

3. A rope is thrown over a beam and one end is ties to a 300 N object. You pull the free end of the rope a distance of 2 meters with a force of 400 N to lift the object off the ground. How much work have you done?

4. A 150 N person rides a 60 N bicycle a total of 200 m at a constant speed. How much work is done?

5. You must exert a force of 4.5 N on a book to slide it across a table. If you do 2.7 Joules of work in the process, how far have you moved the book? (hint: rearrange the work equation for distance)

Power is a measure of how much work is done in a certain period of time. The faster work is done, the more power is produced. The formula for power is: **Power (watts) = Work (J) / Time (sec) OR P=W/t**

6. A machine does 1500 J of work in 30 seconds. What is the power output for this machine?

7. A horse does 1800 J of work pulling a wagon. If the horse pulls this wagon for one hour, how much power does the horse produce? (Remember to convert hours to seconds before calculating).

8. 500 J of work are performed within 15 seconds of time. How much power is produced?

9. A 190,000 Watt engine can accelerate from rest to a top speed within 9 seconds. How much work did the engine doe? (hint: solve the power equation for work).

10. A runner exerts 350 J of work and makes 125 W of power during a training run. How long did it take the runner to complete the run? (hint: solve the power equation for time)

The following questions will require the calculation of Work and Power (use the equations from above). Show all Work!

11. Suppose you and a friend needed to move two 500 N piles of potting soil to a garden that is 100 meters away. You accomplished this task in 10 minutes while your friend required 30 minutes to move the soil.

- **a.** Calculate the work done by you and by your friend in Newtons (remember to convert minutes to sec.)

- **b.** Calculate your power output and your friend's power output in Watts.

12. A weightlifter lifts a 1250 N barbell 2 meters in 3 seconds. Find the work done and the power output.

13. A crane lifts a 35,000 N steel girder a distance of 25 meters in 45 seconds. How much work did the crane do?

14. A machine lifts a load of steel that weights 9.3×10^5 N over a distance of 100 meters. It takes 5 minutes to complete the task. Calculated the work done and the power produced by the machine. (convert min to sec)

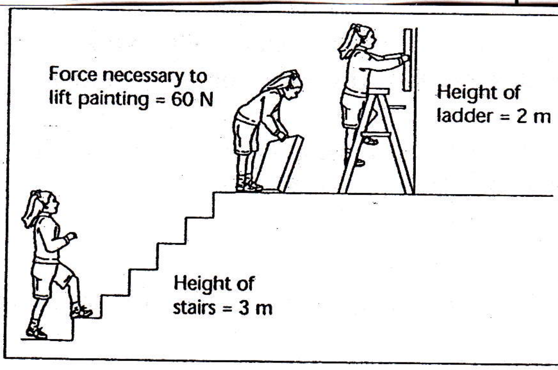
15. A 700 Watt gasoline engine and a 300 Watt electric motor both do 3 joules of work. Which machine can do the work faster? Explain your answer.

16. In the English system, the unit of power is "horsepower". It is based on the amount of work an average horse can do. (1 horsepower = 746 Watts).

- **a.** If a car engine is rated at 125 horsepower, how many watts of power does it produce?

- **b.** If a lawnmower engine is rated at 4 horsepower, how many watts of power does it produce?

17. Use the image below to calculate work done and power output for the event depicted.



Step 1: A 50 N girl climbs the flight of stairs in 3 seconds.

Work = ______________________

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Power = ______________________

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Step 2: The girl lifts a painting to a height of 0.5 m in 0.75 seconds.

Work= ______________________

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Power= ______________________

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Step 3: The girl climbs the ladder with the painting in 5 seconds.

Work= ______________________

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Power= ______________________

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