Name:_____ Lab Partner: _____

Survey of Physics

806-139

Lab 9: Simple Machines

Purpose: For several different simple machines, you will make measurements to determine the input and output force, ideal mechanical advantage (*IMA*), actual mechanical advantage (*AMA*), and efficiency.

Introduction:

For any machine, mechanical advantage describes how much the input force is changed in magnitude to become output force. When not including the effects of friction, we call this **ideal mechanical advantage**, and it turns out to be the ratio of input distance to output distance, given in the equation below. This is always true, but there is often an easier way to make measurements on a machine and calculate *IMA* without actually working the machine.

$$IMA = \frac{s_{out}}{s_{in}}$$

Friction in the machine usually causes the input force to be larger than if there were no friction, which reduces the **actual mechanical advantage**, the ratio of output force to input force, given in the equation below. These forces do need to be measured directly to find *AMA*.

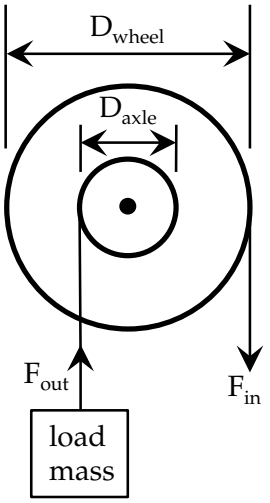
$$AMA = \frac{F_{out}}{F_{in}}$$

Machines never produce **more** actual output work (output force times output distance) than input work (input force times input distance), and usually produce **less** due to friction in the machine. The efficiency of the machine is the percentage of input work that is converted to output work. Efficiency can be calculated most easily as the ratio of actual to ideal mechanical advantage:

$$e = \frac{AMA}{IMA} \times 100$$

For each machine used in this lab, the output force will be the weight force, in newtons, of the mass lifted. The load mass will be one kilogram or more for each machine, and you will calculate the weight force in newtons for the load mass used in each trial.

Part A: Wheel and Axle



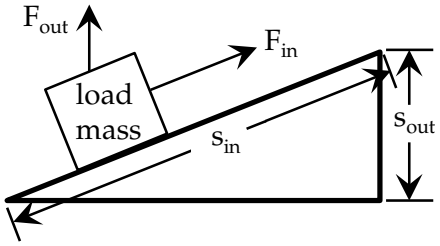
For the wheel and axle, the input force usually acts on a larger diameter cylinder (the wheel) than the output force (the axle). The ideal mechanical advantage for a wheel and axle is calculated from the ratio of the input wheel diameter to the output axle diameter:

$$IMA = \frac{D_{wheel}}{D_{axle}}$$

Procedure: Do two trials, using a different combination of wheel and axle diameters for each trial. Measure diameters and forces, then calculate IMA, AMA and efficiency. Show all results in the data table, and **show your calculations for one trial here**:

	D_{wheel}	D_{axle}	F_{out}	F_{in}	*IMA*	*AMA*	*e*
Trial 1							
Trial 2							

Part B: Inclined Plane



For the inclined plane, the input distance is the slant length of the plane and the output distance is the height. The ideal mechanical advantage is:

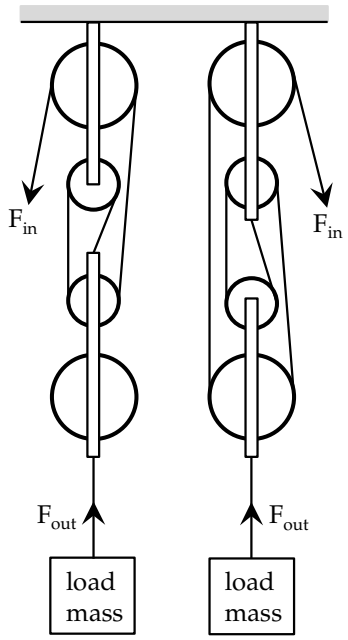
$$IMA = \frac{s_{in}}{s_{out}} = \frac{1}{\frac{opp}{hyp}} = \frac{1}{\sin\theta}$$

Procedure: Do four trials. The first two will be at a low angle between 10° and 20°. Use a wheeled cart with masses for one (low friction) and use a wood box with masses for the other (high friction). Add enough mass to the load so it is **more** than one kilogram. The second two trials will be at a larger angle, greater than 25°. Use the same cart and box for low friction and high friction trials. Measure the angle and forces, then calculate *IMA, AMA* and efficiency. **Show your calculations for one trial here:**

Results table for inclined plane:

	θ	load mass	F_{out}	F_{in}	*IMA*	*AMA*	*e*
Trial 1 (low friction)							
Trial 2 (high friction)							
Trial 3 (low friction)							
Trial 4 (high friction)							

Part C: Pulleys



For pulley systems, the ideal mechanical advantage is equal to the number of lifting strands between the load pulleys and the upper fixed pulleys.

IMA = number of support strands

Procedure: Pulley systems are prepared with load masses and different numbers of lifting strands. Do three trials with different systems. **Be careful with the pulley setups! If the strings slip off the pulleys, you will have to restring them.** Measure the input force with the force sensor (be sure to tare the force sensor at the same angle you use to pull the input strand). Calculate the IMA, AMA and efficiency. Show all results in the data table, and **show your calculations for one trial here:**

	# of lifting strands	F_{out}	F_{in}	*IMA*	*AMA*	*e*
Trial 1						
Trial 2						
Trial 3						