Exercise 3.2 Calculating Mechanical Advantage

Objective

At the conclusion of this exercise, you will be able to do the following:

1. Identify the six simple machines.
2. Calculate the slope, ideal mechanical advantage (IMA), actual mechanical advantage (AMA), efficiency, ideal effort force, and actual effort force of an inclined plane.
3. Calculate the slope, ideal mechanical advantage (IMA), actual mechanical advantage (AMA), load capacity, and ideal effort force of a wedge.
4. Identify the three classes of levers.
5. Calculate the ideal mechanical advantage (IMA), actual mechanical advantage (AMA), ideal effort force, and actual effort force of a lever.
6. Calculate the ideal mechanical advantage (IMA), actual mechanical advantage (AMA), ideal effort force, and actual effort force of a wheel and axle system.
7. Calculate the ideal mechanical advantage (IMA), actual mechanical advantage (AMA), effort rope length, ideal effort force, and actual effort force of a pulley system.
8. Determine the pitch of a screw thread.
9. Calculate the ideal mechanical advantage (IMA), efficiency, ideal effort force, and actual effort force of a screw.

Procedure

Read the section on mechanical advantage in Chapter 3, "The Mechanical Advantage" in the *Principles of Engineering* textbook.

Problem 3.1 The inclined plane shown in Figure 3-3 is used to move load L a vertical distance h. The actual amount of effort force that is required to move the load up the inclined surface is 50 lb. Complete the following exercises using the values L = 100 lb; θ = 25°, and h = 42 in. Show your math work in the spaces provided.

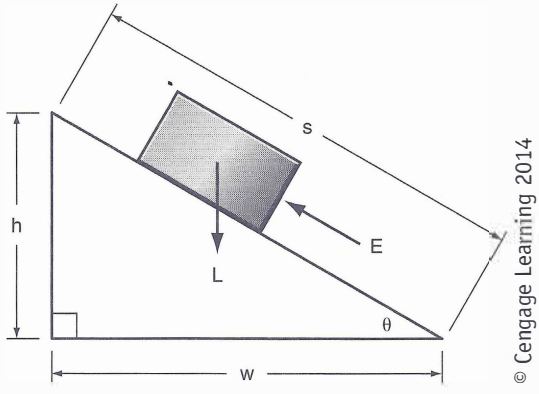

FIGURE 3-3 *An inclined plane.*

1. Calculate the length, *s*, of the inclined plane's slope.

$s =$ _____

2. Calculate the ideal mechanical advantage (IMA) of the inclined plane.

IMA = _____

3. Calculate the actual mechanical advantage (AMA) of the inclined plane.

AMA = _____

4. What is the efficiency (η) of this inclined plane system?

η = _____

5. What is the ideal effort force (E_I) that would be needed to push the load up the inclined plane in the absence of friction?

E_I = _____

Problem 3.2 The table shown in Figure 3-4 contains data that describe four inclined planes, A, B, C, and D. Use the information provided to calculate the missing data for each of the four inclined planes. Show your math work in the spaces provided.

	Load Weight (lb)	Slope Length (in)	Inclined Plane Height (in)	Inclined Plane Width (in)	Slope Angle (degrees)	E_I Ideal Effort Force (lb)	E_A Actual Effort Force (lb)	IMA Ideal Mechanical Advantage	AMA Actual Mechanical Advantage	η Efficiency (%)
A	20.00		8.20	22.65	20.00	6.82	9.89			
B	100.00	24.00			20.00			2.90	2.20	
C			96.00	132.54			88.91		1.10	.66
D	50.00		96.00		30.00	25.00		2.00	1.00	

FIGURE 3-4 *A table of inclined planes.*

Inclined Plane A:

Slope length: _____ IMA: _____

AMA: _____ η: _____

Inclined Plane B:

Height: _____ Width: _____

E_I: _____ E_A: _____

η: _____

Inclined Plane C:

Load: _____ Slope length: _____

Slope angle: _____ E_I: _____

IMA: _____

Inclined Plane D:

Slope length: _____ Width: _____

E_A: _____ η: _____

Problem 3.3 A hydraulic-powered log splitter, like the one shown in Figure 3-5A, is used to cut large logs in half. A wedge, located on one end of the device, provides the cutting action. The shape of the wedge is an isosceles triangle that is 6 in. thick by 12 in. wide. An *actual* effort force of 300 lb is required to split a log. The cutting action of the wedge is 80% efficient. Use this information to answer the following questions. Show your math work in the spaces provided.

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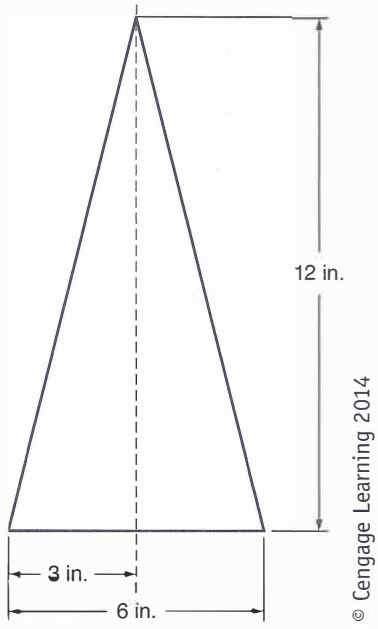
(A)



(B)

FIGURE 3-5 *(A) Log splitter and (B) wedge profile.*

1. What is the slope length (s) on either side of the wedge?

s = _____

2. What is the ideal mechanical advantage (IMA) of the wedge?

IMA = _____

3. What is the actual mechanical advantage (AMA) of the wedge?

AMA = _____

4. How much resistance does the log provide against the cutting action of the wedge?

Load = _____

5. If friction is not a consideration, what would the ideal effort force (E_I) need to be to split the log?

E_I = _____

Problem 3.4 Levers X, Y, and Z in Figure 3-6 represent three different lever systems. Identify which of these three lever systems is described in each of the statements below. Write the answers and justification for each selection in the spaces provided.

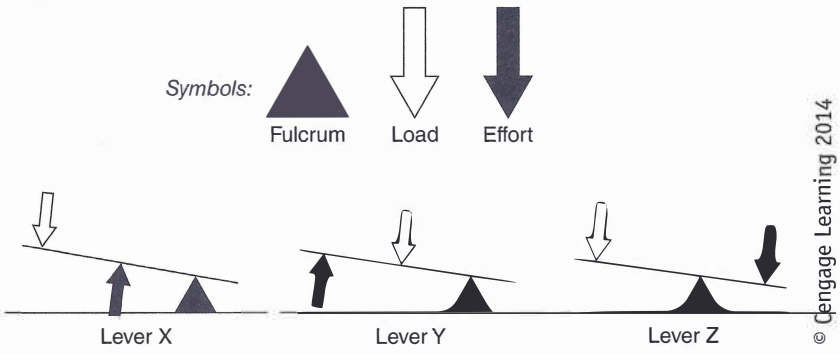


FIGURE 3-6 *Lever systems X, Y, and Z.*

1. This system represents a class of lever that always has a mechanical *disadvantage.*

_____

Explain your selection.

_____

_____

2. This represents a class of lever that always has a mechanical *advantage.*

_____

Explain your selection.

_____

_____

3. This is an example of a first-class lever.

_____

Explain your selection.

_____

_____

4. This is an example of a second-class lever.

_____

Explain your selection.

_____

_____

5. This is an example of a third-class lever.

_____

Explain your selection.

_____

_____

Problem 3.5 The lever in Figure 3-7 has an efficiency of 75%. The load on the lever is 150 lb. Use this information to answer the following questions. Show your math work in the spaces provided.

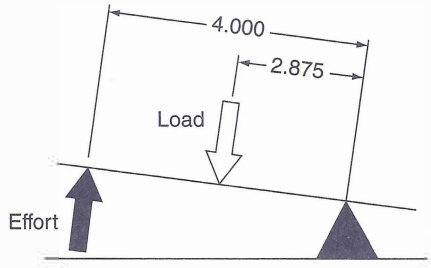


FIGURE 3-7 *A lever.*

1. Figure 3-7 is an example of what class of lever?

_____

2. What is the ideal mechanical advantage (IMA) of the lever?

IMA = _____

3. What is the actual mechanical advantage (AMA) of this system?

AMA = _____

4. What is the *ideal effort force* (E_I) that would be needed to move the lever in the absence of friction?

E_I = _____

5. What is the actual effort force (E_A) that must be applied to the lever to move the load?

E_A = _____

6. How could you alter this machine to increase its ideal mechanical advantage (IMA)?

_____

_____

Problem 3.6 In Figure 3-8, a 40-lb bucket of water is being raised from a deep well using a winch system that is 85% efficient. The winch axle diameter is 4 in., and the crank handle is located 12 in. from the center axis of the axle. Use this information to answer the following questions. Show your math work in the spaces provided.

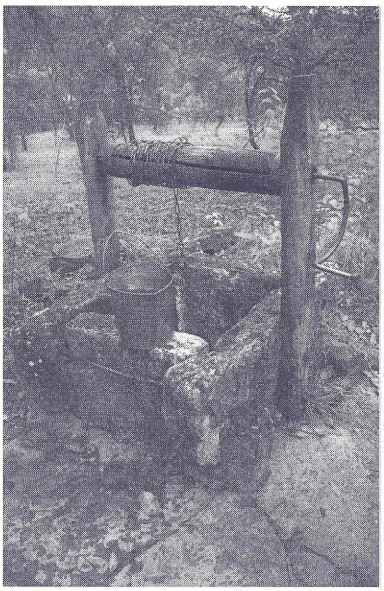


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FIGURE 3-8 *A wheel and axle system.*

1. What is the ideal mechanical advantage (IMA) of the wheel and axle?

IMA = _____

2. What is the actual mechanical advantage (AMA) of the wheel and axle?

AMA = _____

3. Under *ideal* conditions, how much effort must be applied to the crank handle to raise the bucket of water?

E_I = _____

4. What is the *actual* amount of effort force (E_A) that must be applied to the crank handle to raise the bucket of water?

E_A = _____

Problem 3.7 The pulley system in Figure 3-9 is 70% efficient. The 160-lb load must be moved a vertical distance of 72 in. Use this information to answer the following questions. Show your math work in the spaces provided.

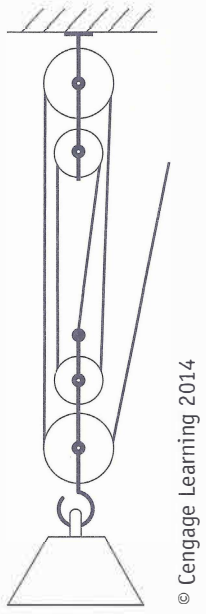

FIGURE 3-9 *A pulley system.*

1. What is the ideal mechanical advantage (IMA) of this pulley system?

   IMA = _____

2. What is the actual mechanical advantage (AMA) of this pulley system?

   AMA = _____

3. What is the length of the effort cable (d_E) that must pass through the user's hands to raise the load to the desired height?

   d_E = _____

4. What is the ideal effort force (E_I) that would be needed to move the load using the pulley system?

   E_I = _____

5. What is the actual effort force (E_A) that would be needed to move the load using the pulley system?

   E_A = _____

Problem 3.8 The vise in Figure 3-10 contains a 3/8-16 UNC-threaded rod. A 500-lb holding force can be generated by turning the 4-in.-long handle. The actual mechanical advantage (AMA) of the machine is 250. Use this information to answer the following questions. Show your math work in the spaces provided.

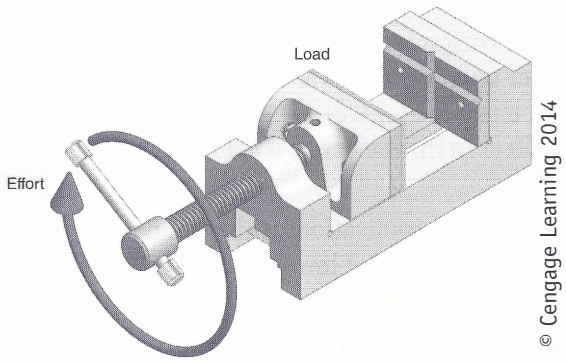

FIGURE 3-10 *A screw-actuated vise.*

1. What is the pitch of the screw thread? *See Equation 3-14 in your textbook.*

   p = _____

2. What is the ideal mechanical advantage (IMA) of the screw?

   IMA = _____

3. What is the efficiency (η) of the screw system?

   η = _____

4. What is the ideal effort force (E_I) that must be applied to the vise handle to hold a load?

   E_I = _____

5. What is the actual effort force (E_A) that must be applied to the vise handle to hold a load?

   E_A = _____