CHAPTER 5

Work and Machines

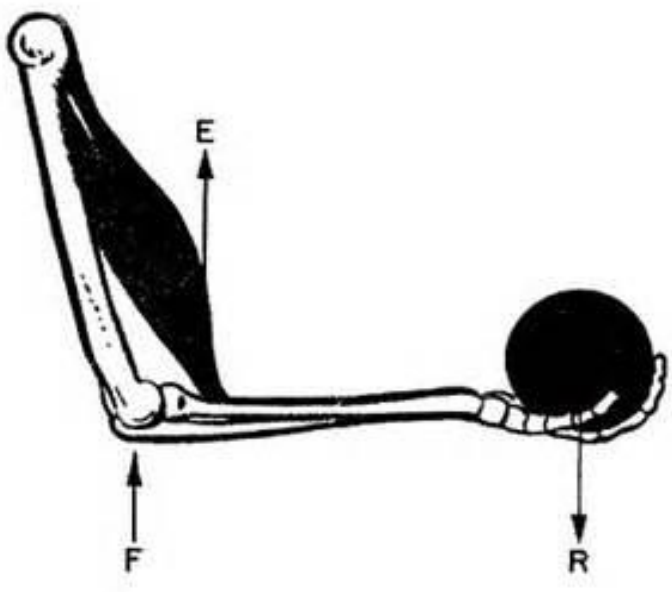


Figure 1-6.-Your arm is a lever.

Physical Science Vocabulary

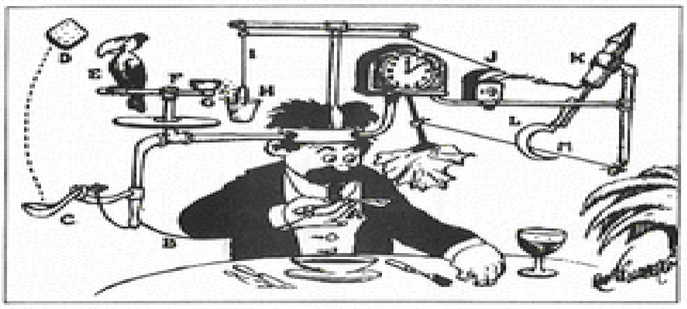
Vocabulary for Chapter 5 - Work and Machines

No.#	Term	Page #	Definition
1.	Compound Machine		
2.	Efficiency		
3.	Inclined Plane		
4.	Input force		
5.	Lever		
6.	Machine		
7.	Mechanical Advantage		
8.	Output Force		
9.	Power		
10	Pulley		
11	Screw		
12	Simple Machine		
13	Wedge		
14	Wheel & Axle		
15	Work		

Rube Goldberg's Machines

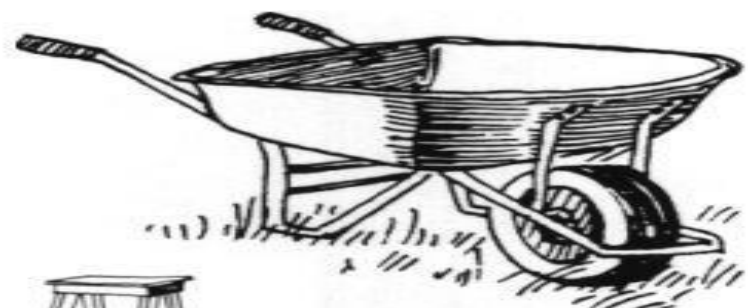
Rube Goldberg was an American cartoonist in the early 1900s. He became famous making cartoons like the one below. In them a simple or silly task is accomplished in an extremely complicated and humorous way. His machine for a self-operating napkin uses a parrot, alarm clock and fireworks!

Self-Operating Napkin



Rube Goldberg's Self-Operating Napkin from 1915

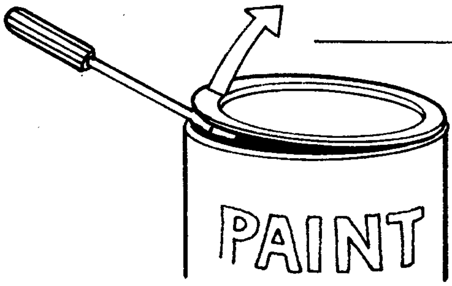
Using the six simple machines (pulley, lever, wedge, screw, inclined plane and wheel & axle) can you make your own **Rube Goldberg machine?** Think of an everyday task you would like to accomplish, and make a machine for it using all six of the simple machines.



TYPES OF LEVERS

Name ____________________

Classify the following levers as first, second or third class.



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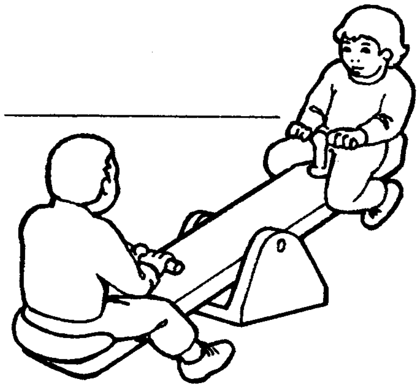

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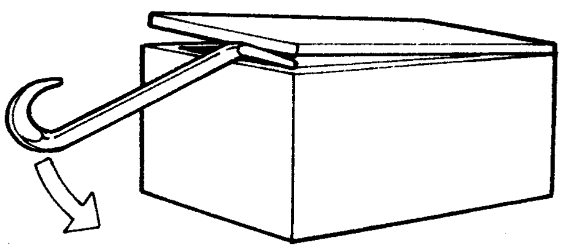

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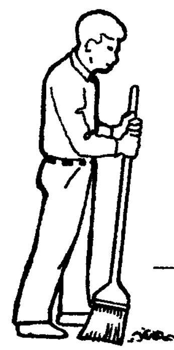

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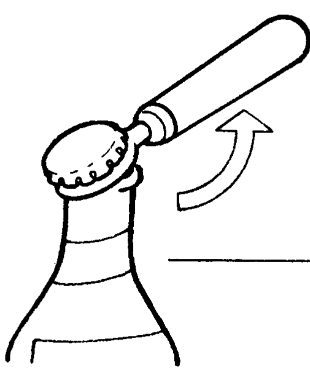

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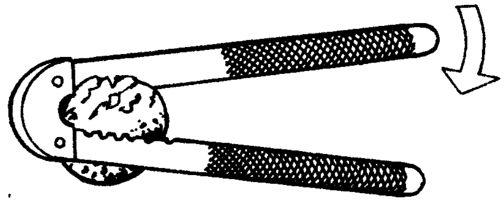

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Broughton High School

The Force of Friction

Section 1: Turn to page 70 in your textbook: "Glencoe Science" – Physical Science

1. A skateboard that has been pushed will slow down and finally ______________________. When an object slows down it is ____.
2. According to Newton's ________________ Law, if the skateboard is accelerating, there must be a ________________________ ___________________________ acting on it. That force that slows the skateboard down is ____.
3. This force _________________________________ the sliding motion of two _____________________ that are touching each other and it depends on the ___________________________________ pressing the surfaces together and the ____________________________________ of surfaces that are touching.
4. (Pg. 71) When something is too heavy to lift, you might try pushing it. If it doesn't move even though you are pushing on it, then the acceleration is ____. This means the net force is ____.
5. According to Newton's _________ Law it takes a net force to produce ____________________________.
6. What is another force that cancels the force of your push? _______________________________________.
7. (Pg. 72) Suppose a friend helps you push the heavy object and pushing together, the objects moves. ___________________________________ acts in the direction opposite the motion of the heavy object.
8. To keep the object moving you must continually apply a ____ to overcome the ____.
9. As a wheel rolls over a surface the wheel digs into the surface. _______________________ ____________________________ is the frictional force between a rolling object and the surface it is on.
10. (Pg. 73) Fluid friction is the friction between an object and the air or water. A friction-like force called ____ opposes the motion of objects that move through the air.

Explain the forces of wind on stationary objects?

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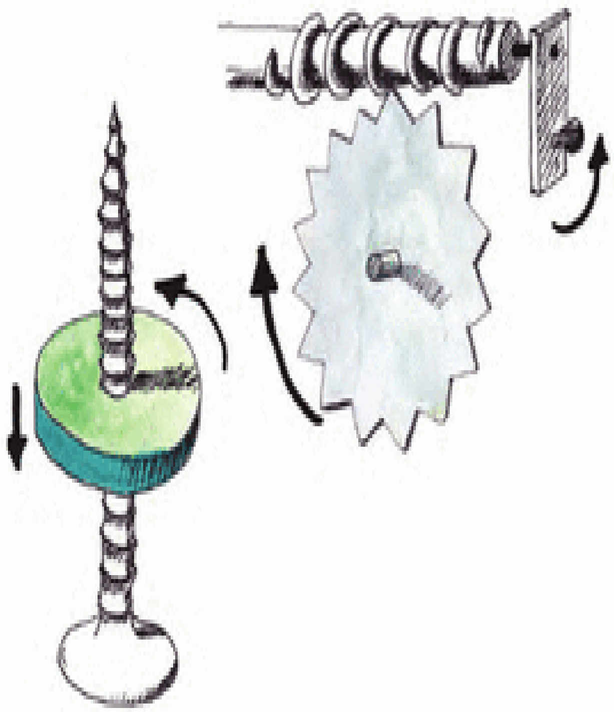
____
____
____
____
____

Screw

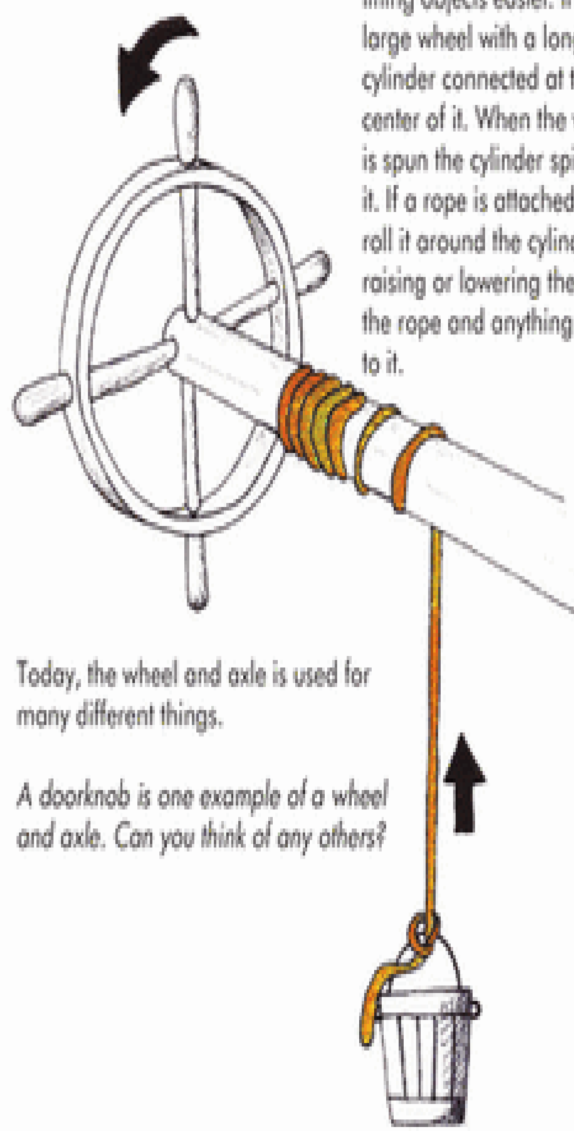
A **screw** is a cylinder with threads spiraling down it. A screw turns a twisting motion into straight motion. When a screw is turned into wood the wood is moved up or down in a straight line along the screw and is stopped by the head.

A corkscrew is one example of a screw. Can you think of any others?



Wheel & Axle

The **wheel and axle** is a machine used to help make lifting objects easier. It is a large wheel with a long cylinder connected at the center of it. When the wheel is spun the cylinder spins with it. If a rope is attached it will roll it around the cylinder, raising or lowering the end of the rope and anything attached to it.



Today, the wheel and axle is used for many different things.

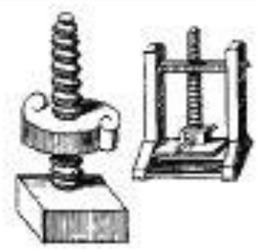
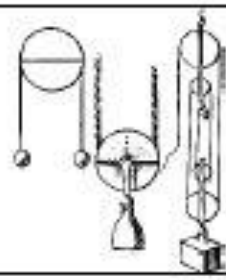
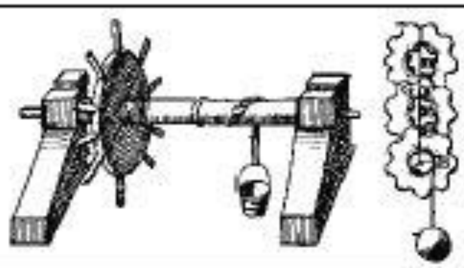
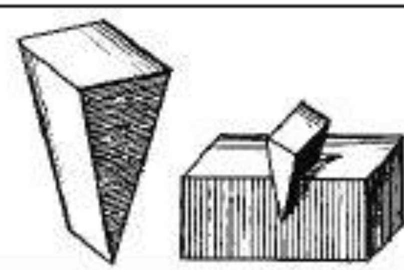
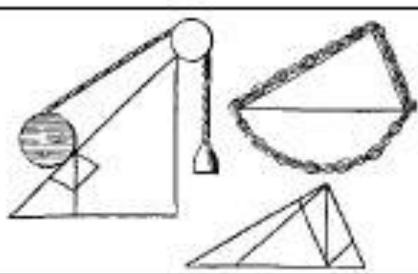
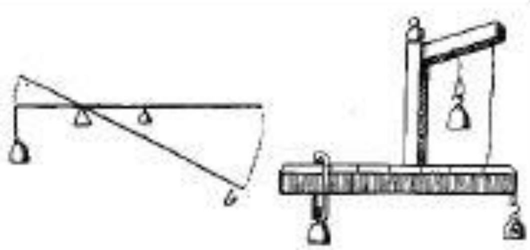
A doorknob is one example of a wheel and axle. Can you think of any others?

Name: ______________________________

The Six Simple Machines

Directions: Correctly label the six simple machines.

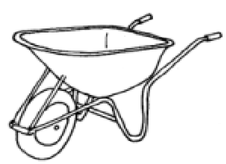
(1) inclined plane　(3) pulley　(5) wedge
(2) lever　(4) screw　(6) wheel and axle

Section 2: Classify the following types of friction that might occur in each of these situations.

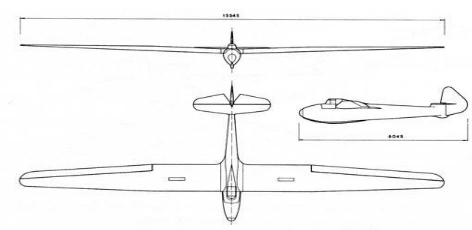
F = Fluid Friction ST = Static Friction SL = Sliding Friction R = Rolling Friction

11. _________ a boat moving through a river
12. _________ riding your bike
13. _________ cartilage moves against bone
14. _________ a rocket jets through the atmosphere
15. _________ you push a car with the emergency brake on
16. _________ ice skating
17. _________ sitting in a chair at a computer
18. _________ duck glides through a pond
19. _________ using a mouse pad while navigating the computer screen
20. _________ gears (cogs) on a wheel turn
21. _________ the surface of a waiter's tray keeps the glass and pie in place
22. _________ fish swim in an aquarium
23. _________ a tennis ball sticks to Velcro
24. _________ a tennis ball rolls off the court
25. _________ a housewife can't move the refrigerator
26. _________ playing air hockey

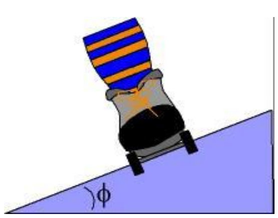
27. _________ 

31. _________ 

28. _________ 

32. _________ 

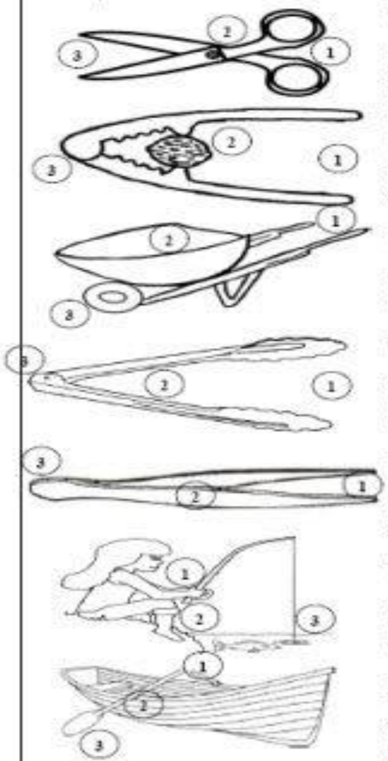
29. _________ hydroplaning with water under the car tires

30. _________ 

33. _________ 

Identify the lever and label the load, effort and fulcrum.

Name________________________



Type of Lever ____________________
1.
2.
3.

Type of Lever ____________________
1.
2.
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Type of Lever ____________________
1.
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Type of Lever ____________________
1.
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Type of Lever ____________________
1.
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3.

Type of Lever ____________________
1.
2.
3.

Type of Lever ____________________
1.
2.
3.

Find The Simple Machines

Find and color the six simple machines in these bedroom scenes.

- ☐ pulley
- ☐ lever
- ☐ wedge
- ☐ screw
- ☐ inclined plane
- ☐ wheel & axle

6 Types Simple Machines

1. A **pulley** is a simple machine that uses grooved wheels and a rope to raise, lower or move a load. A pulley is a type of simple machine that uses a wheel with a groove in it and a rope. The rope fits into the groove and one end of the rope goes around the load.

2. A **lever** is a stiff bar that rests on a support called a fulcrum which lifts or moves loads. The lever is made up of a straight rigid object like a board or a bar which pivots on a turning point called a fulcrum.

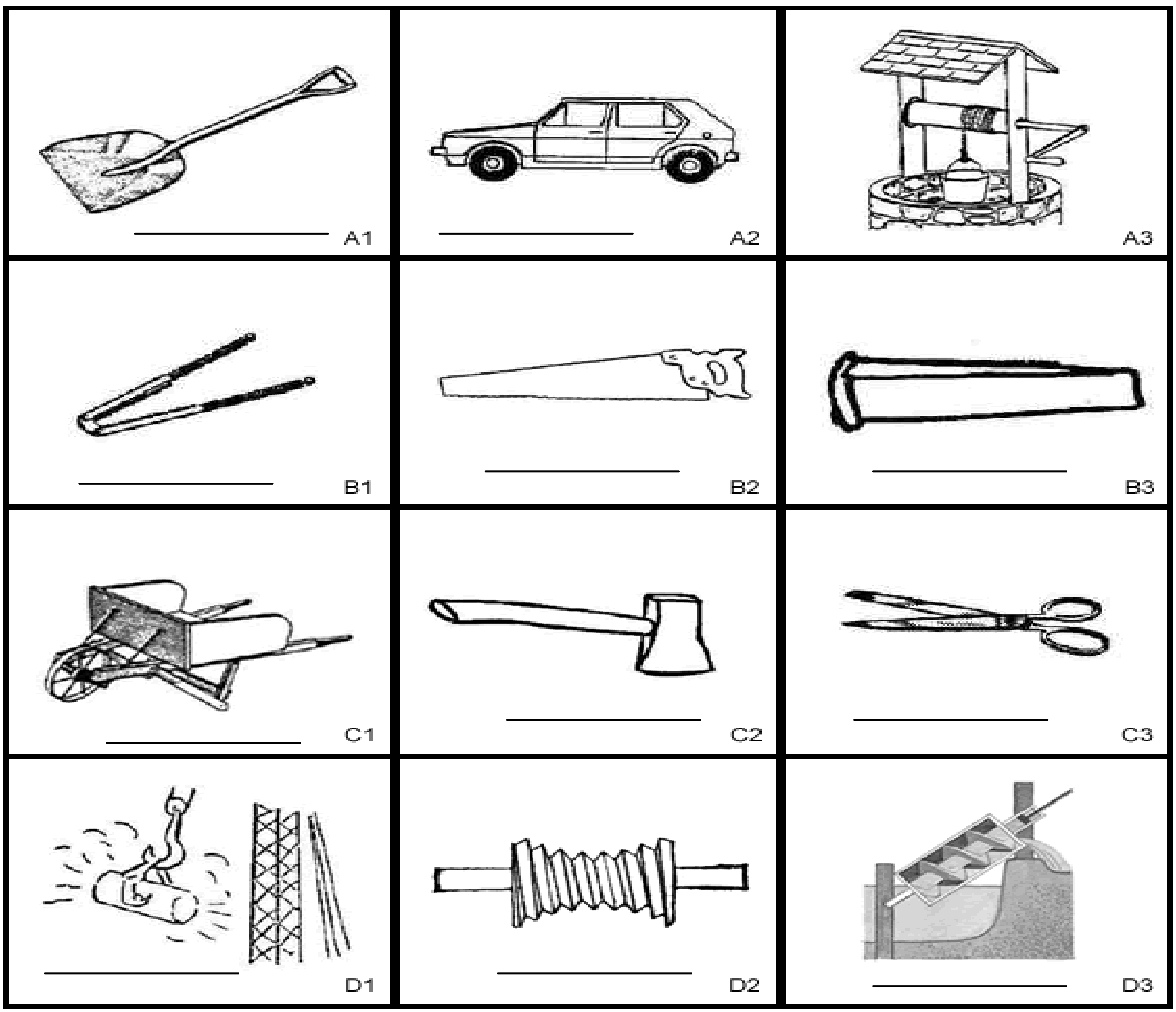
3. A **wedge** is an object with at least one slanting side ending in a sharp edge, which cuts material apart. If you put two inclined planes back to back, you get a wedge. A wedge is a simple machine used to push two objects apart.

4. A **wheel with an axle**, through its center lifts or moves loads.

5. An **inclined plane** is a slanting surface connecting a lower level to a higher level. An inclined plane is a flat surface with one end higher than the other. This allows for heavy objects to be slid up to a higher point rather than to be lifted. It's easier to slide something than to lift it.

6. A **screw** is an inclined plane wrapped around a pole which holds things together or lifts materials. A screw is a special kind of inclined plane. It's basically an inclined plane wrapped around a pole. Screws can be used to lift things or hold them together.

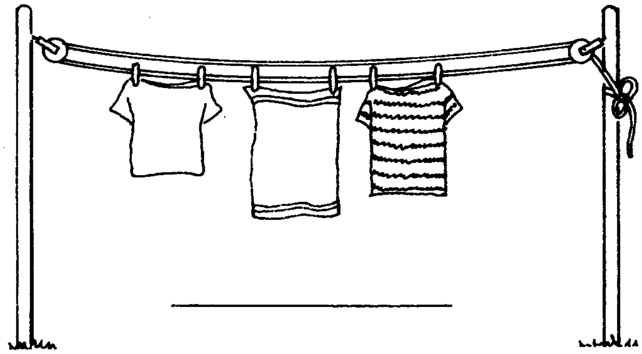
Section 3: Identify the follow pictures as a type of machine.

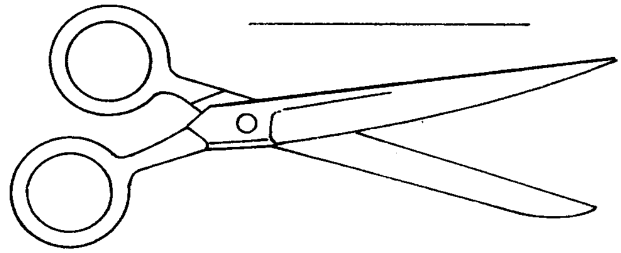


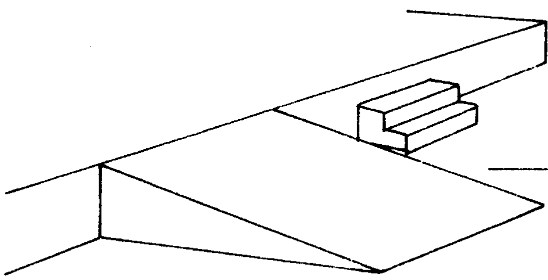
SIMPLE MACHINES

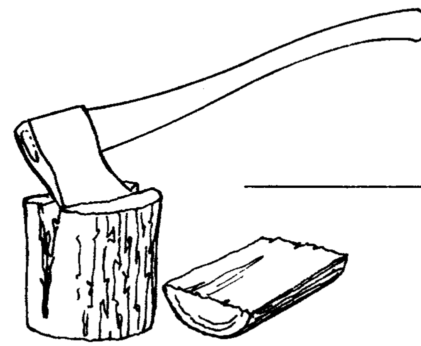
Name ____________________

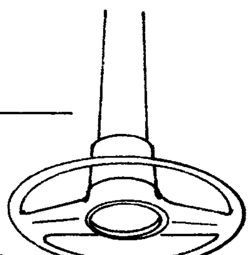
What types of simple machines are shown in the following pictures?

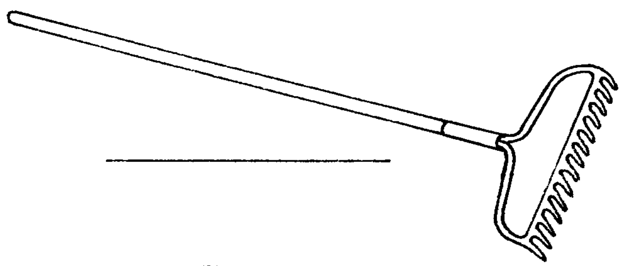


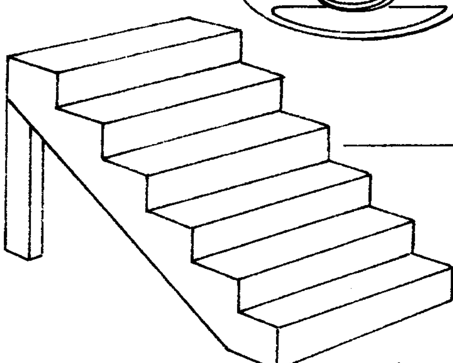


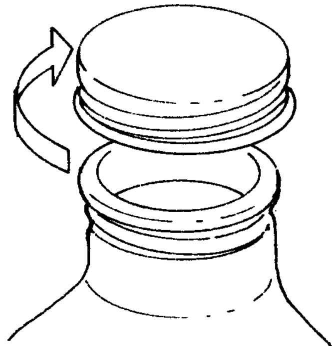


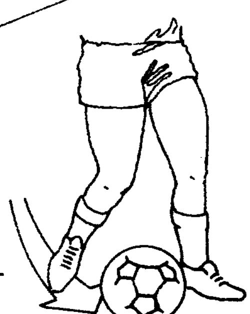


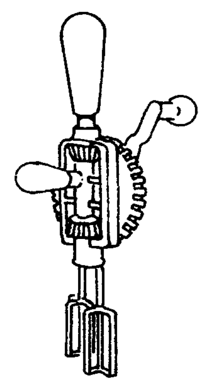




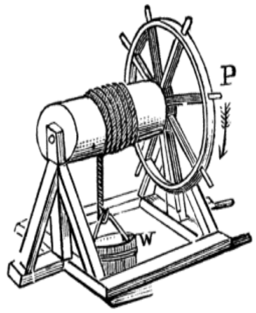


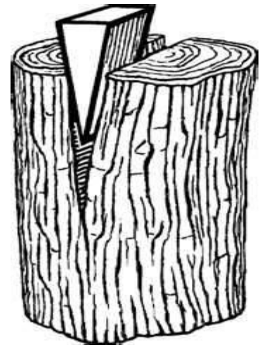


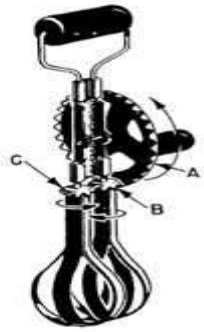


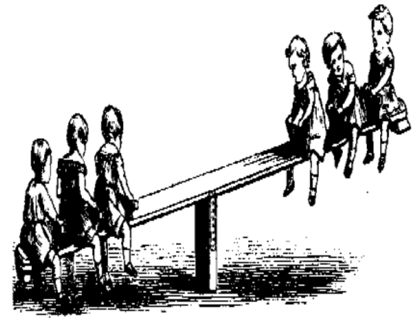


Section 4: Identify each picture as a type of simple machine.

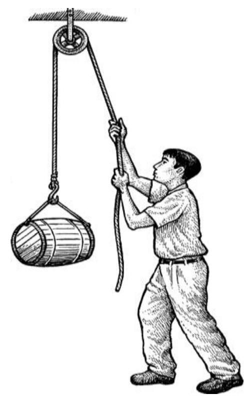


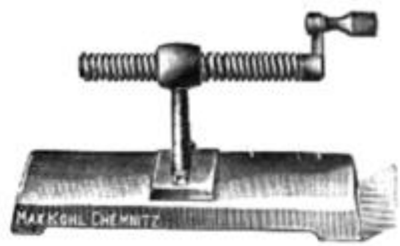




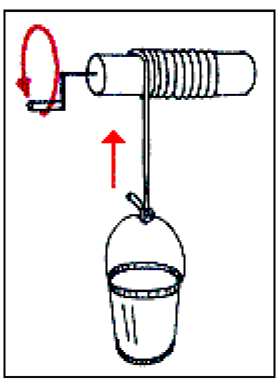


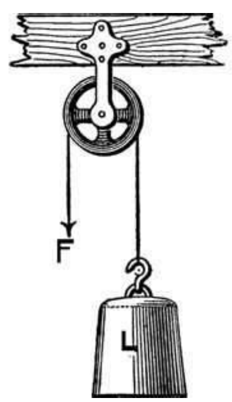
____________________ ____________________ ____________ ____________________

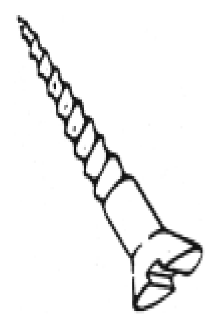




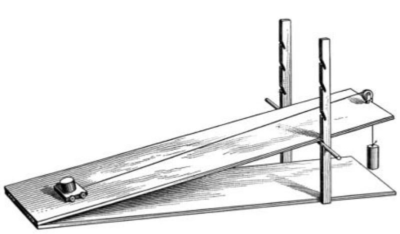
____________________ ______________ ____________________ ____________________

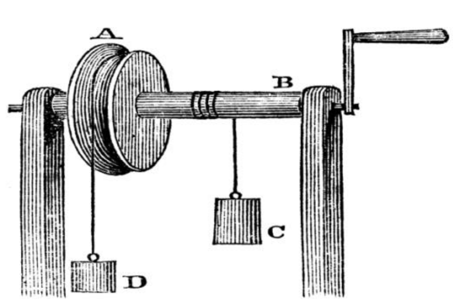






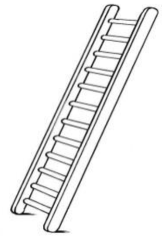
____________________ ____________________ ______________ ______________





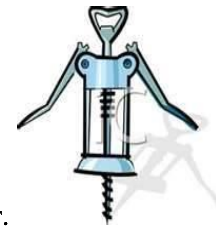
______________________________ ______________________ ____________________

Section 5: Identify each type of simple machine

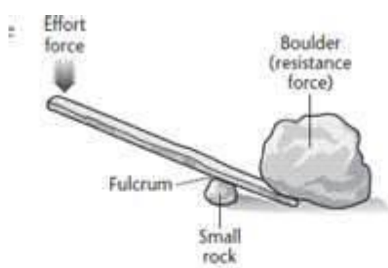


1. It is slanted surface that works like a ramp to lift things. ____________________

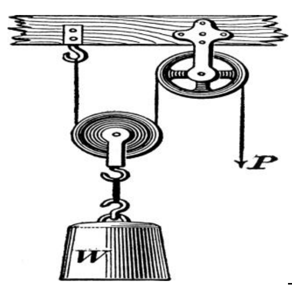
2. It is pair of inclined planes back-to-back that works to force things apart. ___________



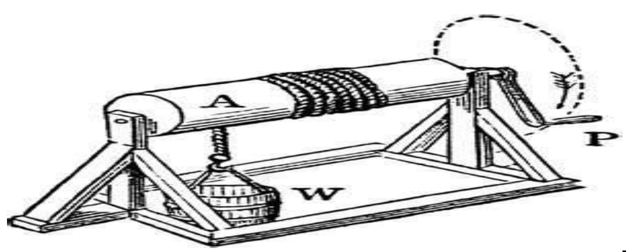
3. It is an incline spirally wrapped around a cylinder used to fasten things together. _________



4. It is a bar that pivots around a fixed point (Fulcrum). FIGURE 3.5. Lifting a Boulder with a Wooden Lever ________________



5. It is grooved wheel with a rope, cord, or chain through it. ___________________



6. It is a large and small wheel attached to a rod. ___________

Section 6: Simple Machines Matching: Use Pulley, Inclined Plane, Screw, Wedge, & Lever

7. Pliers _______________
8. Ramp _______________
9. Spiral Staircase ________
10. Chisel _______________
11. Rake _______________
12. Used to hoist a flag _________
13. Tack _______________
14. Boat propeller ______________
15. Door stop ______________
16. Bottle opener ______________
17. Seesaw ______________
18. Front of a boat ______________
19. Step stool ______________
20. Flight of stairs ______________

Section 7: Short Definitions

21. Define fulcrum: ____
22. If an inclined plane is made steeper, what does that do to the mechanical advantage?

____

23. What is the formula for Mechanical advantage? ____
24. An inclined plane: ____
25. A pulley: ____
26. A lever: ____
27. What are the differences between FIXED PULLEY and MOVABLE PULLEY?

____

____

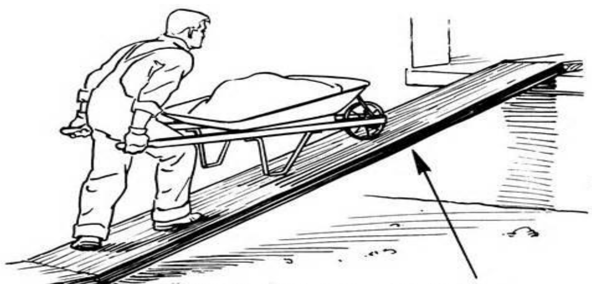
28. Define "Compound Machine" ____
29. Define Wedge: ____
30. Define Efficiency: ____
31. How would you define the simple machine known as the screw: _________________________________?
32. What is transferred to an object when work is done? ____
33. Define lever: ____
34. Define simple machine: ____

Inclined Planes

Inclined planes are also called ramps. They make it easier to move things to a higher location.

Try to lift the basket with your hands, it's heavy! Next, try to move the basket up the ramp by pushing it, and then pulling it up with the rope. Which is the easiest way to move the basket?

With your grown up's help, add more blocks to the stack to make the ramp higher. Is it easier or harder to move the basket when the ramp is higher?



W	X	W	O	L	W	C	X	Z	H	D	G	R	Z	U
Y	B	S	M	T	E	U	T	E	N	B	A	Q	C	G
S	C	L	Y	G	Z	E	D	G	F	U	X	Y	I	P
F	U	N	G	J	D	G	H	U	G	V	L	N	I	M
P	O	U	E	A	X	I	P	W	I	V	E	E	L	U
C	U	R	J	I	M	D	N	C	O	T	X	W	P	R
C	B	L	C	W	C	L	W	C	Z	M	R	T	O	C
A	U	Y	L	E	O	I	S	A	L	W	U	O	W	L
V	L	W	Y	E	G	R	F	X	T	I	Z	N	E	U
R	K	E	Q	O	Y	V	K	F	A	T	N	S	R	F
V	D	F	V	R	N	Z	R	Q	E	V	S	E	L	G
E	P	K	Z	E	D	M	A	C	H	I	N	E	D	O
C	W	I	V	A	R	B	M	J	W	E	R	C	S	D
P	K	Q	I	C	A	G	H	R	M	C	X	N	R	M
F	W	T	R	W	T	U	S	E	L	U	O	J	K	U

MACHINE
EFFICIENCY
INCLINED
FORCE
WORK
POWER
LEVER
PULLEY
SCREW
WHEEL
AXLE
JOULES
NEWTONS
WATTS
FULCRUM

Kinetic & Potential Energy

$KE = \frac{1}{2}mv^2$ $\quad PE = mgh = F_g h$ $\quad W = F\Delta d$ $\quad P = \frac{W}{\Delta t} = \frac{F\Delta d}{\Delta t}$

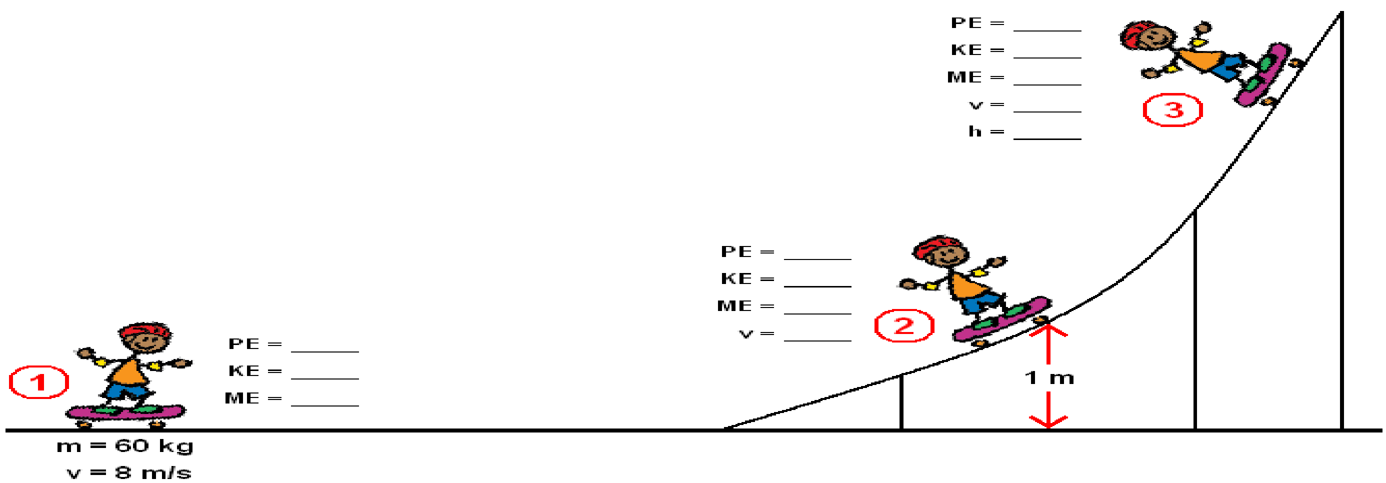
35. Which has more kinetic energy: a 15,000 kg truck traveling at 40 m/s or a 10,000 kg car traveling at 65 m/s?

Formula	Set Up & Solve	Answer

36. A 5kg book is perched on a 71m above the floor. How much stored energy does that book possess?

Formula	Set Up & Solve	Answer

37. Calculate the potential energy, kinetic energy, mechanical energy, velocity, and height of the skater at the various locations.

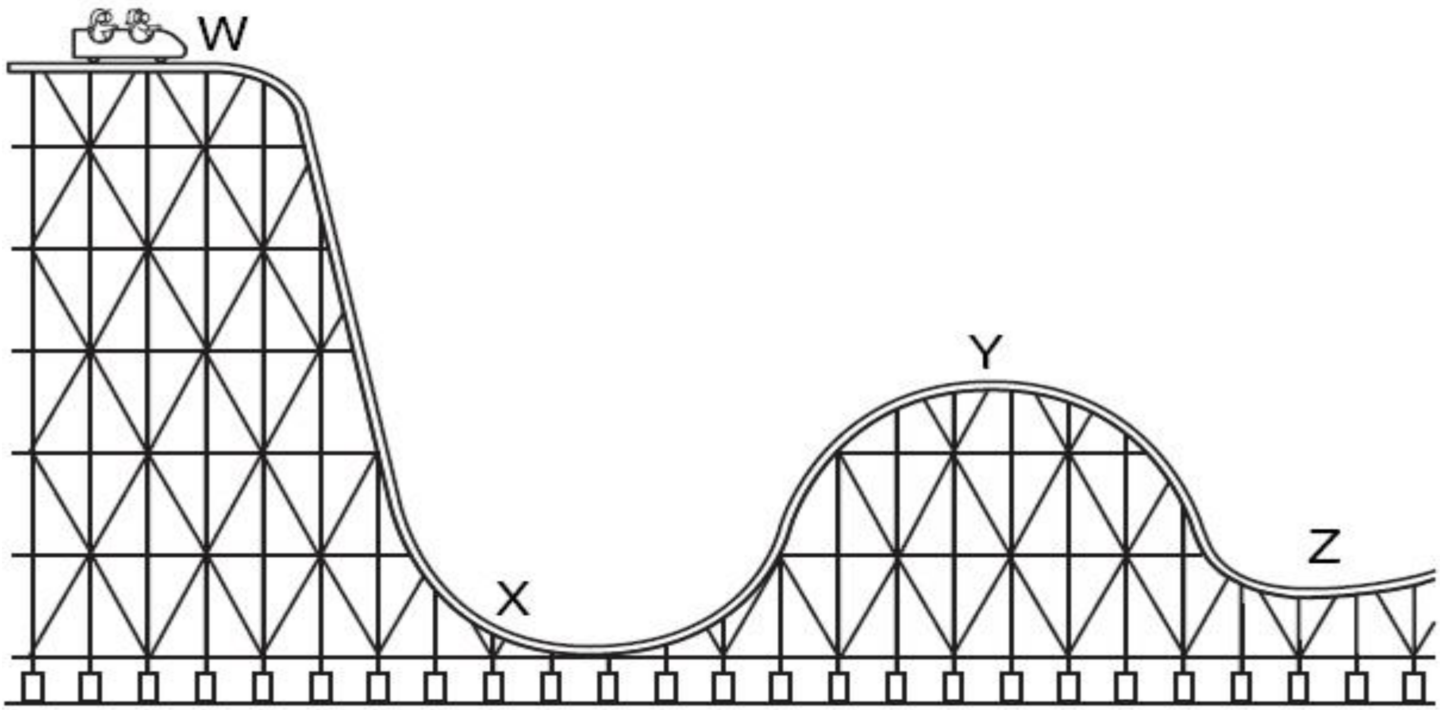


	Potential Energy	Kinetic Energy	Velocity	Mechanical Energy	Height
1					
2					
3					

Kinetic & Potential Energy

$KE = \frac{1}{2}mv^2$ $PE = mgh = F_g h$ $W = F\Delta d$ $P = \frac{W}{\Delta t} = \frac{F\Delta d}{\Delta t}$

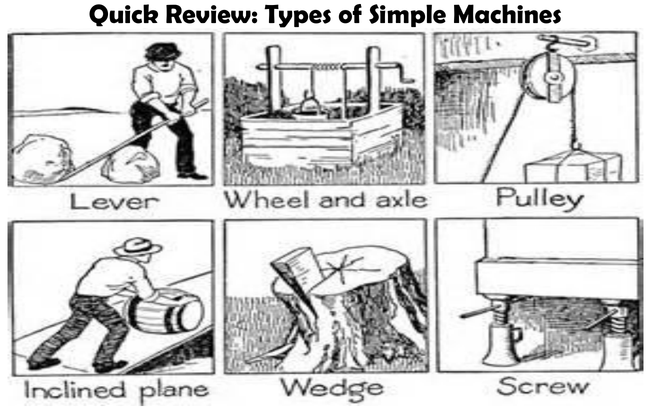
38. Describe the Potential Energy and Kinetic Energy conversions in a roller coaster ride.



Select: Maximum PE Minimum PE Maximum KE Minimum KE

Position W	Position X	Position Y	Position Z

Quick Review: Types of Simple Machines



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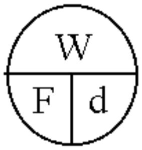
Work & Power I

Section 8: Problems



$$\text{Power} = \frac{\text{Work}}{\text{time interval}}$$

39. How much power is required to lift a chair that weighs 40.0N a distance of 0.25m in 2.1 seconds?

Formula	**Set Up & Solve**	**Answer**

40. A boy exerts a force of 56 N when he lifts a box 1.2 meters. How much work does he do?

Formula	**Set Up & Solve**	**Answer**

41. A man pushes a parked car with a force of 175N and the car does not move. How much work does the man do?

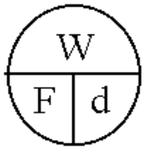
Formula	**Set Up & Solve**	**Answer**

42. How much power is required to do 340J of work in 6.4 seconds?

Formula	**Set Up & Solve**	**Answer**

43. If 300J of work lifts a 20N object, how far has it been moved?

Formula	**Set Up & Solve**	**Answer**



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Work & Power II

$$\text{Power} = \frac{\text{Work}}{\text{time interval}}$$

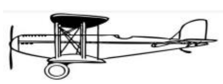
44. A box weighing 60N is lifted 1.5m. How much work is done?

Formula	Set Up & Solve	Answer

45. A small machine does 750J of work in 35 seconds. How much power does the machine supply?

Formula	Set Up & Solve	Answer

Section 9: Problems



What forces are acting against the flight of this plane?

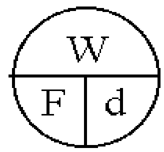
46. **Directions**: Complete the chart below by filling in the missing quantities.

Force (Newton's)	Distance (meters)	Time (seconds)	Work (Joules)	Power (Watts)
10	6	4		
	4	5		50
30			600	300
500	10			100
	16	8	64	
100	0.5			25
200		2	100	
	50	30	1500	
800	100			4000

Calculating Efficiency I

Section 10: Problems - What is the efficiency of the following machines?

The amount of **work output from a machine is always less than the amount of work put into it**. This is because some of the work is lost due to friction. The efficiency of a machine can be calculated using the following formula:



Percent efficiency = $\frac{\text{Work output}}{\text{Work input}} \times 100$

47. A man expands 100 Joules of work to move a box up an inclined plane. The amount of work produced is 80 J.

Formula	Set Up & Solve	Answer

48. A box weighing 100 Newton's is pushed up an inclined plane that is 5 meters long. It takes a force of 75 Newton's to push it to the top, which has a height of 3 meters.

Formula	Set Up & Solve	Answer

49. Using a lever, a person applies 60 Newton's of force and moves the lever 1 meter. This moves a 200 Newton rock at the other end by 0.2 meters.

Formula	Set Up & Solve	Answer

Why is the Energy Star Rating of a washing Machine important?

____
____
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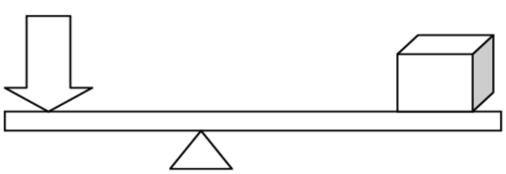
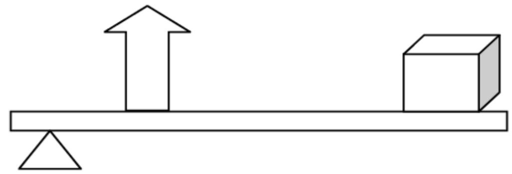
Worksheet Packet – Simple Machines

Identify the class of each lever shown below. Label the effort force, resistance force, and fulcrum.



1. ______________________________



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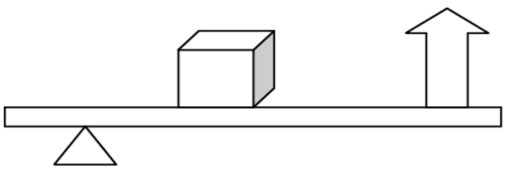
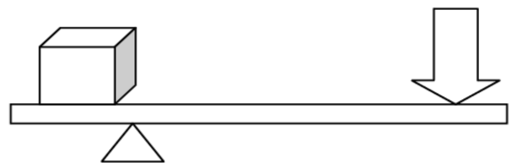


3. _______________________________



4. _____________________________

5. Which of the above levers would be the most efficient at lifting a heavy block of granite?_________

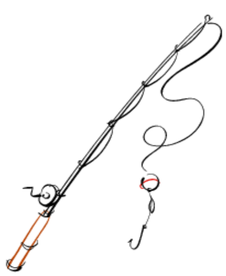
Identify the class of each level in the drawing. Draw a line to indicate the position of the fulcrum, resistance arm, and effort arm using the monikers F, R, and E.

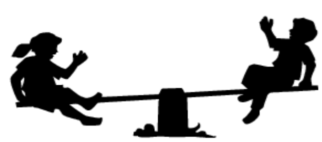
6. Bottle Opener ____________

7. Pliers _________

8. Broom ________

9. Fishing Pole ________

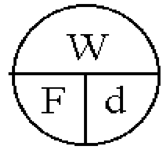




10. Seesaw ____________

11. Wheelbarrow _______

Calculating Efficiency II



Percent efficiency = $\frac{\text{Work output}}{\text{Work input}} \times 100$

50. A boy pushes a lever down 2 meters with a force of 75 Newton's. The box at the other end with a weight of 50 Newton's moves up 2.5 meters.

Formula	Set Up & Solve	Answer

51. A person in a wheelchair exerts a force of 25 Newton's to go up a ramp that is 10 meters long. The weight of the person and wheelchair is 60 Newton's and the height of the ramp is 3 meters.

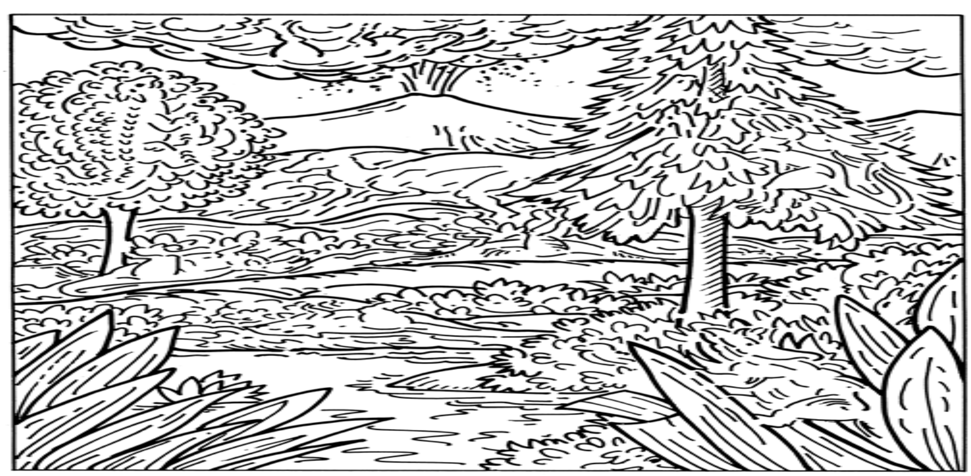
Formula	Set Up & Solve	Answer

52. A pulley system operates with 40% efficiency. If the work put it is 200 joules, how much useful work is produced?

Formula	Set Up & Solve	Answer

How many dinosaurs can you find?

____
____
____



Section 11: Problems

Efficiency I

Efficiency = (AMA /IMA) X 100 IMA = d_E / d_R AMA = F_R / F_E

53. You apply 1 150 N effort force to lift a TV a height of 2m using a ramp that is 12 meters long. The TV weighs 782 N. What is the efficiency of the machine?

IMA	AMA	Efficiency

54. You apply an effort force of only 730N to push a chest of drawers weighing 4933N along a 9m long ramp to lift it up to a porch that is 1.2 m high. Calculate the efficiency?

IMA	AMA	Efficiency

55. What is the efficiency of a lever if a person uses an effort force of 33.3N to raise on object that weighs 90N? They use a lever with an effort arm length of 6m while the resistance arm length is 2m.

IMA	AMA	Efficiency

56. A box that weighs 95N is lifted using an effort force of 20N. The lever that helps the people do the work has an effort arm length of 50cm and a resistance arm length of 10cm. Calculate the efficiency.

IMA	AMA	Efficiency

57. Calculate the efficiency of a lever that has an effort arm length of 5ft. and a resistance arm length of 2 foot if an object weighing 112N was lifted using an effort force of only 20N.

IMA	AMA	Efficiency

Efficiency II

Efficiency = (AMA /IMA) X 100 IMA = d_E / d_R AMA = F_R / F_E

58. An object weighting 270 n was lifted to a height of 3ft. using a ramp that was 9 feet long. The effort force was only 122 N. Calculate the efficiency.

IMA	AMA	Efficiency

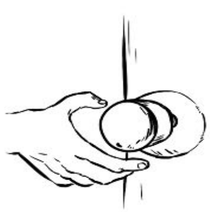
59. An inclined plane that is 25m long and 5m high was used to lift a 100 N object using an effort force of 25 Newton's. Calculate the efficiency?

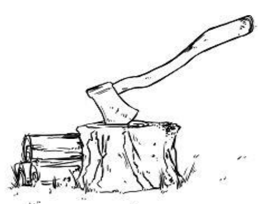
IMA	AMA	Efficiency

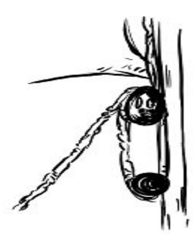
60. A box weighting 80N was lifted to a height of 12 ft. using an incline that was 36 feet long. The effort force required was only 30 N. Calculate the efficiency.

IMA	AMA	Efficiency

Identify the different types of machines?







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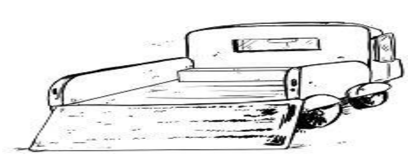

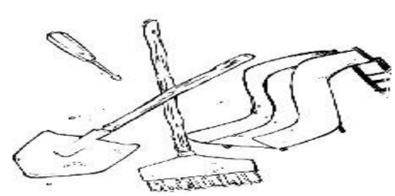

____________________________ ________________________________

Efficiency III

61. A person uses a pulley to raise a flag up a 15 m flagpole. The weight of the flag is 45N and the person pulls down on the rope with a effort force of 50 N through a distance of 15 m.

IMA	AMA	Efficiency

62. A person exerts a force of 180 N through a distance of 0.5 m using a automobile jack to raise a 3600 N car a distance of 0.01 m up.

IMA	AMA	Efficiency

63. By exerting a force of 250 N through a distance of 0.6m., a person using a crowbar can lift the corner of a heavy machine which 14,250 N a distance of 0.01 meters.

IMA	AMA	Efficiency

Section 12: Problems

Problem	Resistance (Newton's)	Effort (Newton's)	AMA	Effort Distance	Resistance Distance	IMA	% Efficiency
61							
62							
63							

64. In which problem did the machine have the greatest AMA? ______________________________________

65. In which problem did the machine have the greatest efficiency? __________________________________

66. Explain why no machine can be 100% efficient.

____
____
____
____
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Mechanical Advantage I

Section 13: Problems

HINT: 1st Calculate IMA $\quad\quad$ IMA = d_E / d_R

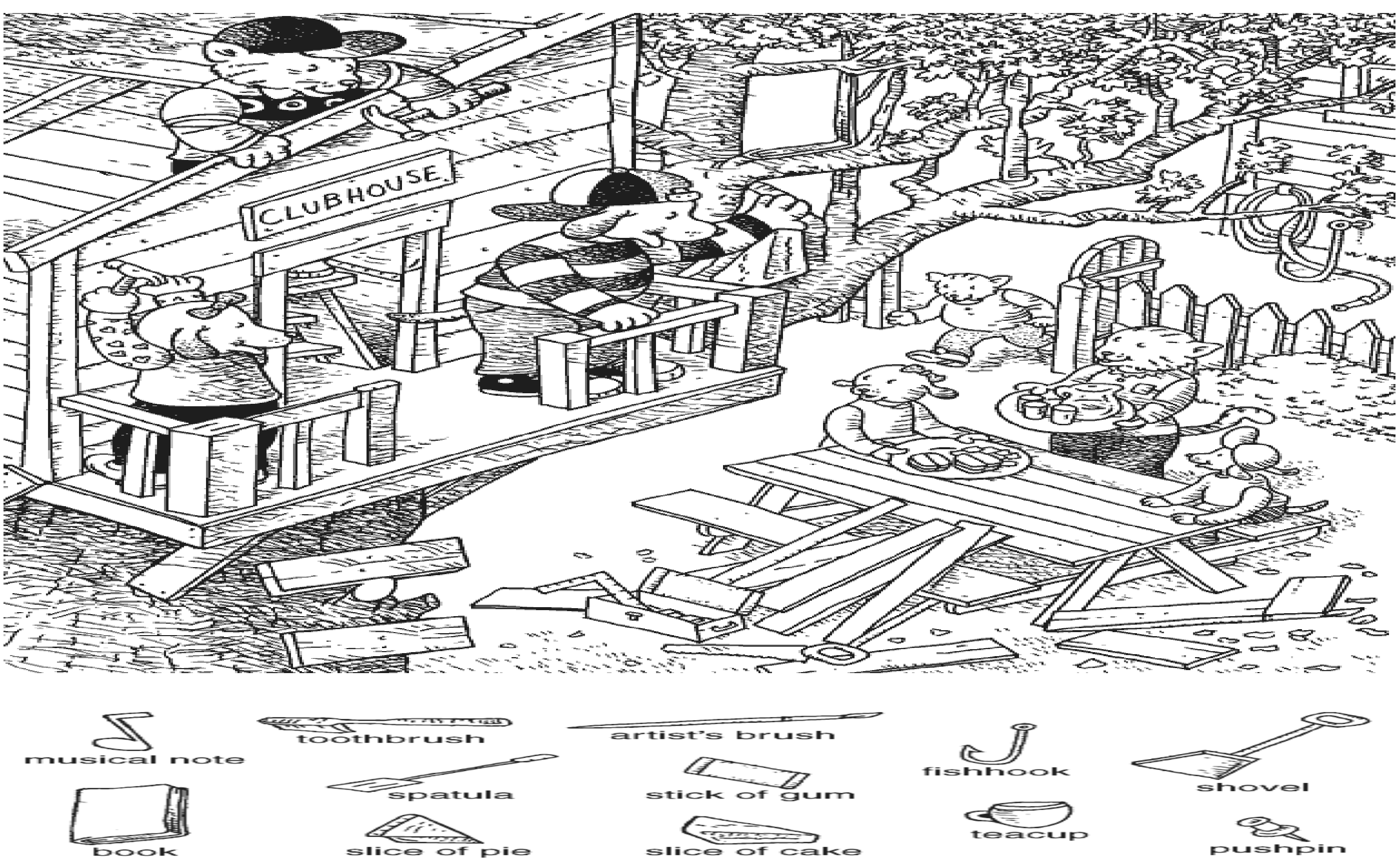
67. You see a ramp that's 24 meters long to lift a heavy box to a height of 5 meters. IMA: ______________
68. The effort arm of a lever is 37 meters while the resistance is 12 meters from the fulcrum. IMA: _______
69. You use a lever with a 15 meter effort arm and a fulcrum that's 7 meter from the resistance. IMA: _____
70. The ramp you use to lift a heavy object 4 meter is 18 meter long. IMA: ___________________________
71. You apply and effort to turn a wheel 12 cm while the resistance of the axle turns 1.5 cm. IMA: _______

Section 11: Problems

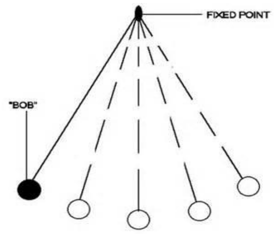
HINT: 2nd Calculate AMA $\quad\quad$ AMA = F_R / F_E

72. You use a machine to lift an object that weighs 105 N with effort force of 33 N. AMA: ______________
73. An object that weighs 35 N is lifted with an effort force of only 15 N using a machine. AMA: ________
74. It takes an effort force of just 20 N to lift an object that weighs 325 N using a machine. AMA: ________
75. You apply an effort force of 75 N to lift a box that weighs 596 N. AMA: _________________________
76. You push with an effort force of 55N to raise a load that weighs 128 N. AMA: ____________________

Find the Hidden Pictures



Mechanical Energy Worksheet



Mechanical Energy Worksheet

$PE = mgh$ $KE = ½mv^2$

1. What are the two main forms of mechanical energy?

2. A car is lifted a certain distance in a service station and therefore has potential energy relative to the floor. If it were lifted twice as high, how much potential energy would it have?

3. Two cars are lifted to the same elevation in a service station. If one car is twice as massive as the other, how do their potential energies compare?

4. How many joules of potential energy does a 1-N book gain when it is elevated 4 m? When it is elevated 8 m?

5. A moving car has kinetic energy. If it speeds up until it is going four times as fast, how much kinetic energy does it have in comparison?

6. Consider a ball thrown straight up in the air. At what position is its kinetic energy a maximum? Where is its gravitational potential energy a maximum?

7. At what point in its motion is the KE of a pendulum bob a maximum? At what point is its PE a maximum? When its KE is half its maximum value, how much PE does it have?

8. What is the kinetic energy of a 2 kg snow ball thrown through the air at 5 m/s?

Mechanical Energy Worksheet

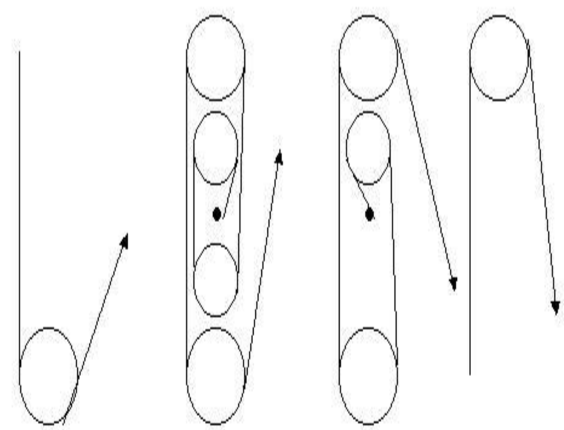
$PE = mgh$ $KE = ½mv^2$

1 What are the two main forms of mechanical energy?

Sample Problems

Mechanical Advantage of the pulley

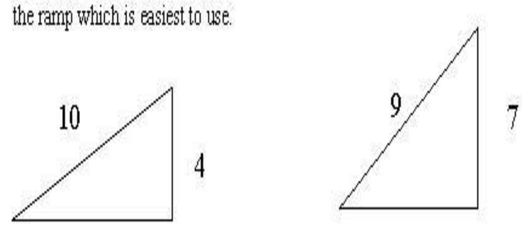
Write the mechanical advantage of each pulley in the space provided
Circle the pulley which is easiest to use.



MA=___ MA=___ MA=___ MA=___

Mechanical Advantage of the inclined plane

Write the mechanical advantage of each ramp in the space provided. Circle the ramp which is easiest to use.



MA=___ MA=___

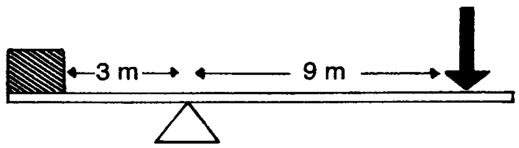
MECHANICAL ADVANTAGE

Name ____________________

What is the mechanical advantage of the following simple machines?

$MA = \frac{F_R}{F_E}$ where F_R = resistance force
F_E = effort force

1.



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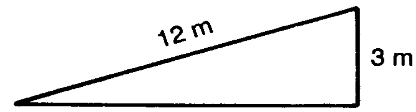

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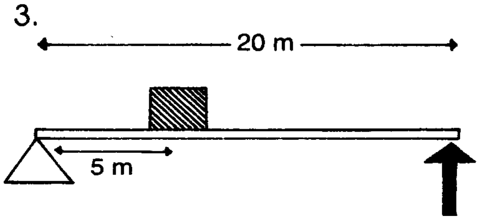

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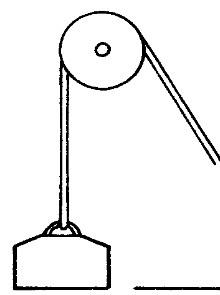

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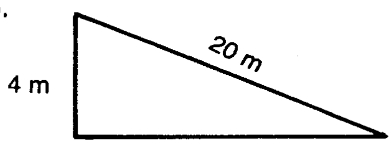

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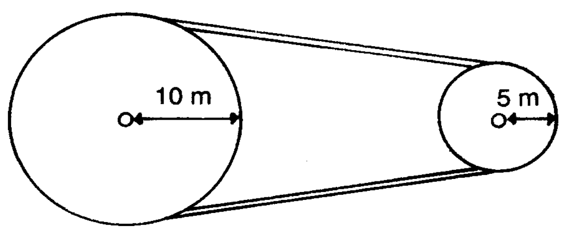

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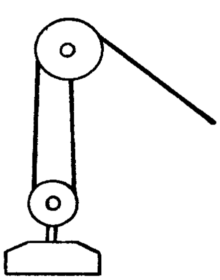

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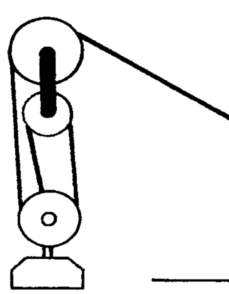

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