Conceptual Physics: Form TR6.19A Name ________________________________

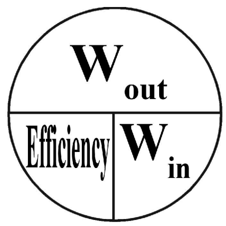
MACHINES Date __________________ Period _____

Test Review № 6

Efficiency. According to the law of conservation of energy, you can never get more out of a machine than you put into it. But you can certainly waste energy overcoming friction. Friction reduces the work output, making it less than the work input. The efficiency is the ratio of the work output to the work input.

$$efficiency = \frac{work\ output}{work\ input} \times 100\%$$

$$eff = \frac{W_{out}}{W_{in}} \times 100\%$$



(*NOTE*: Express efficiency as a decimal to calculate W_{out} or W_{in}.)

Sample Problem

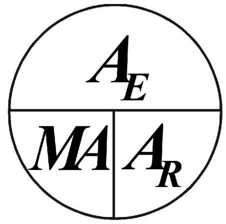
A machine has an efficiency of 65 percent. How much work was done to accomplish 143 J of work?

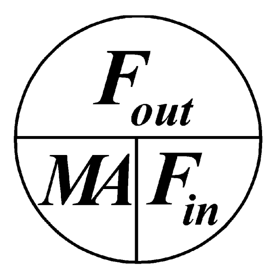
$$eff = \frac{W_{out}}{W_{in}};\ 0.65 = \frac{143J}{W_{in}};\ W_{in} = \frac{143J}{0.65} = 220J$$

Simple Machines. A machine is a device that changes the direction or magnitude and distance through which a force operates. A **simple machine** is a machine that does work with only one movement. Examples include an inclined plane, a lever, a wheel and axle, and a pulley. An inclined plane is a ramp. A plank leading from the ground into a truck is an inclined plane. A lever is a rigid rod that rotates about a fixed point or fulcrum, such as a crowbar or a bottle opener. A wheel and axle consists of two objects of different size attached in such a way that they rotate around the same axis. A wheel on a bicycle is an obvious example, but so is a screwdriver. A pulley is a grooved wheel with rope or cable. A pulley is used to hoist a flag up a flagpole or sails up the mast. Wedges and screws can also be considered simple machines. A wedge, such as the edge of an axe, is similar to two inclined planes put together, and a screw is similar to a wheel and axle with an inclined plane wrapped around it. A combination of simple machines is called a **compound machine**. An eggbeater or nail clipper is a compound machine.

Lever. A lever is a rod that rotates about a point or fulcrum. There are three types of levers based on the relative placement of the fulcrum, the resistance force, and the effort force. A first class lever such as a crow bar or see saw has a fulcrum between the effort and the resistance. A second class lever such as a wheel barrow or bottle opener has the resistance between the effort and the fulcrum. A third class lever such as a fly swatter or baseball bat has the effort between the resistance and the fulcrum. The region between the fulcrum and the resistance is the **resistance arm** (A_R). The region between the fulcrum and the effort is the **effort arm** (A_E). The product of either the effort force or the resistance force is the **moment** ($M = F \times A$). For a balanced lever, the moments on both sides of the fulcrum are equal. The mechanical advantage of a lever is the ratio of the effort arm to the resistance arm.

$$IMA = \frac{A_E}{A_R}$$





Sample Problems

A meterstick is balanced at the center. If 1.0 N weight is hanging at the 10 cm mark, and a 3.0 N weight is hanging at the 20 cm mark, where does a 5.0 N weight need to be placed?

$$M_1 + M_2 = M_3$$
$$F_1 A_1 + F_2 A_2 = F_3 A_3$$
$$(1.0N)(40cm) + (3.0N)(30cm) = (5.0N)A_3$$
$$40Ncm + 90Ncm = (5.0N)A_3$$
$$130Ncm = (5.0N)A_3$$
$$\frac{130Ncm}{5.0N} = A_3 = 26cm \quad Loc = 50 + 26 = 76cm$$

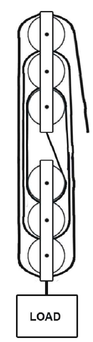
A 3.0 m long wheel barrow has 500 N load 0.6 m from the wheel. Ignoring the weight of the wheel barrow, how much force is needed to lift the end so it can be rolled?

$$IMA = \frac{A_E}{A_R}$$
$$IMA = \frac{3.0m}{0.6m} = 5$$
$$F_{in} = \frac{F_{out}}{MA}$$
$$F_{in} = \frac{500N}{5} = 100N$$

Pulleys. A pulley is a grooved wheel with rope or cable. There are two types of pulleys, fixed pulleys and moveable pulleys. A fixed pulley is a pulley that doesn't move, and changes the direction of the applied force. A moveable pulley is a pulley that is supported by strands of rope along which it slides. A pulley system containing both fixed and moveable pulleys is called a block and tackle. The number of supporting strands of rope the moveable pulley has determines the mechanical advantage. While the mechanical advantage comes from the supporting strands of rope, the pulley, a grooved wheel that glides along the rope, reduces friction.

Sample Problem

Refer to the diagram of the pulley system to the right:



What is the mechanical advantage?

6

How much force is needed to lift a 60 N load?

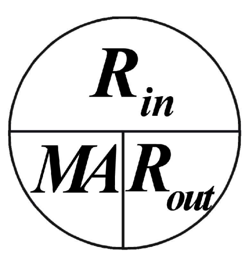
$$F_{in} = \frac{F_{out}}{MA} = \frac{60N}{6} = 10N$$

How much rope will need to be pulled out to lift the load 75 cm?

$$d_{in} = d_{out} \times MA = (75cm)(6) = 450cm$$

Wheel and Axle. A wheel and axle consists of two objects of different size attached in such a way that they rotate around the same axis. Examples include a screw driver, a steering wheel, and a bicycle wheel. A wheel and axle functions similarly to a 2nd or 3rd class lever depending on whether the wheel turns the axle (wheel = input), or the axle turns the wheel (axle = input). The input radius is like the effort arm, while the output radius is like the resistance arm. The ideal mechanical advantage of a wheel and axle is the ratio of the input radius to the out put radius.

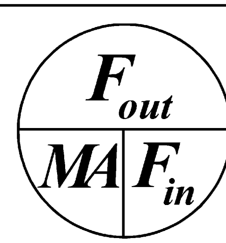
$$IMA = \frac{input\ radius}{output\ radius}$$
$$IMA = \frac{R_{in}}{R_{out}}$$



Turning the wheel by the axle results in a mechanical advantage less than 1, but it also increases the speed. That's why it's easier to walk than ride a bike uphill . But the bike is faster.

Sample Problem

A bucket holding 300 N of water hangs in a well by a rope wrapped around a barrel with a diameter of 8.0 cm. It is raised from the well by a crank with a radius of 50.0 cm. How much force is needed to raise the bucket?



Step 1: Determine the mechanical advantage.

$$MA = \frac{R_{in}}{R_{out}} = \frac{50cm}{4cm} = 12.5$$

Step 2: Determine the output force.

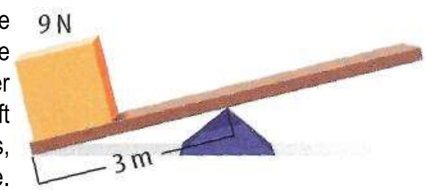
$$F_{in} = \frac{F_{out}}{MA} = \frac{300N}{12.5} = 24N$$

Inclined Planes. An inclined plane is a ramp. It makes work easier because the incline helps to support the weight of the object as it is raised and because the work is done over a greater distance when an object is pushed up an incline rather than lifted. As a result, a smaller force can be used. That doesn't mean you get to do less work using an incline. In fact, you may have to do more, because of friction. The input distance of an incline is its length, while the output distance is its height. The equations for calculating the work output (W_{out}), the work input (W_{in}), the work overcoming friction (W_f), the actual mechanical advantage (AMA), the ideal mechanical advantage (IMA), and the efficiency (Eff) of an incline are shown to the right.

$$W_{out} = F_{out} \times d_{out}$$
$$W_{in} = F_{in} \times D_{in}$$
$$W_f = W_{in} - W_{out}$$
$$AMA = F_{out}/F_{in}$$
$$IMA = d_{in}/d_{out}$$
$$Eff = (W_{out}/W_{in}) \times 100$$
$$Eff = (AMA/IMA) \times 100$$

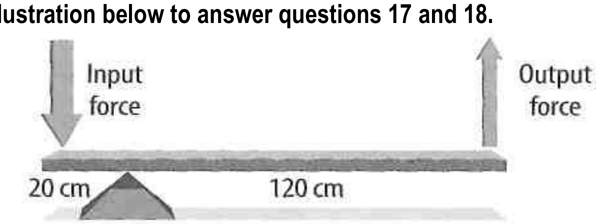
Answer the questions below by circling the number of the correct response

1. The input work done on a pulley system is 450 J. What is the efficiency of the pulley system if the output work is 375 J? (1) 120 % (2) 83.3 % (3) 75 % (4) 16.9 %
2. Which of the following causes the efficiency of a machine to be less than 100%? (1) work (2) power (3) mechanical advantage (4) friction
3. A 60-W light bulb uses 60 J of electrical energy every second. However, only 6 J of electrical energy is converted into light energy each second. What is the efficiency of the light bulb? Give your answer as a percentage. (1) 1 % (2) 100 % (3) 10 % (4) 66 %
4. The work output is 300 J for a machine that is 50% efficient. What is the work input? (1) 600 J (2) 150 J (3) 250 J (4) 350 J
5. A machine is 75% efficient. If 200 J of work are put into the machine, how much work output does it produce? (1) 150 J (2) 267 J (3) 275 J (4) 125 J
6. You can increase a machine's efficiency by decreasing the (1) power. (2) friction. (3) gravity. (4) energy.
7. You build a machine which is 80% efficient. How many joules of work are put into the machine to produce 400 J of output work? (1) 500 J (2) 320 J (3) 0.2 J (4) 480 J
8. An elevator carries a 490 N person up 10 m. The elevator does 7,000 J of input work. What is the efficiency of the elevator? (1) 50% (2) 70% (3) 90% (4) 100%
9. How efficient is a machine with a work output of 85 J and a work input of 255 J? (1) 85 % (2) 33.3 % (3) 170 % (4) 46.75 %
10. A machine has an efficiency of 25 percent. How much work was done to accomplish 150 J of work? (1) 37.5 J (2) 600 J (3) 3750 J (4) 125 J
11. How much useful work was done if a machine with 75 percent efficiency required an input of 800 J? (1) 600 J (2)1067 J (3) 875 J (4) 725 J
12. The input work done on a wheel and axle is 425 J. What is the efficiency of the pulley system if the output work is 320 J? (1) 120 % (2) 83.3 % (3) 75 % (4) 16.9 %
13. Would a 9-N force applied 2 m from the fulcrum of the lever pictured to the right lift the weight? (1) Yes, because it's a machine. (2) Yes, because the mechanical advantage is greater than 1. (3) No, because the mechanical advantage is 1. (4) No because the mechanical advantage is less than 1.



14. How much input force is required to lift an 11,000-N beam using a pulley system with a mechanical advantage of 20? (1) 550 N (2) 220,000 N (3) 11,020 N (4) 10,980 N
15. What is the name of the point about which a lever rotates? (1) input distance (2) output distance (3) fulcrum (4) axle
16. The input and output forces are applied at the ends of the lever. If the lever is 3 m long and the output force is applied 1 m from the fulcrum, what is the mechanical advantage? (1) 1 (2) 2 (3) 3 (4) 4

Use the illustration below to answer questions 17 and 18.



17. What is the mechanical advantage of the lever above? (1) 0.167 (2) 26 (2) 3 (4) 6
18. What would the mechanical advantage of the lever be if the triangular block were moved to a position 35 cm from the edge of the output force side of the plank? (1) 0.333 (2) 0.167 (3) 3 (4) 4

19. A lever has an input force of 5 N and an output force of 15 N. What is the mechanical advantage of the lever? (1) 1 (2) 2 (3) 3 (4) 0.33

20. A simple machine has a mechanical advantage of 5. If the output force is 10 N, what is the input force? (1) 0.5 N (2) 2 N (3) 50 N (4) 15 N

21. You use a rope and pulley system with a mechanical advantage of 5. How big an output load can you lift with an input force of 200 N? (1) 0.25 N (2) 40 N (3) 1,000 N (4) 195 N

Answer questions 22 and 23 referring to a lever that has an input arm 50 cm long and an output arm 20 cm long.

22. What is the mechanical advantage of the lever? (1) 2.5 (2) 30 (3) 70 (4) 1,000

23. If the input force is 100 N, what is the output force? (1) 250 N (2) 3000 N (3) 7000 N (4) 100,000 N

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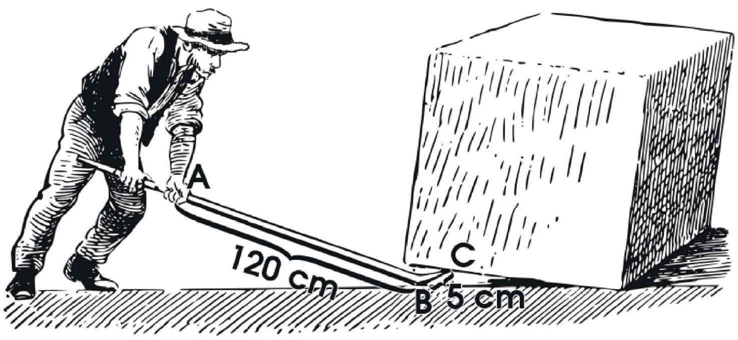
24. A lever is used to lift a heavy rock that weighs 1,000 N. When a 50-N force pushes one end of the lever down 1 m, how far does the load rise? (1) 1 m (2) 20 m (3) 0.05 m (4) 1050 m

Answer questions 25-29 by referring to the diagram below.



25. What type of lever is pictured above? (1) 1^{st} class (2) 2^{nd} class (3$3^{rd}$ class (4) 4^{th} class

26. What represents the fulcrum? (1) A (2) B (3) C (4) none of these

27. What represents the resistance? (1) A (2) B (3) C (4) none of these

28. What is the mechanical advantage? (1) 125 (2) 24 (3) 0.042 115

29. What force would be needed to lift the stone at C if it weighs 36,000 N? (1) 1,500 N (2) 62.5 N (3) 300 N (4) 864,000 N

Use the illustration below to answer questions 30 and 31

30. The pulley system in the illustration above uses several pulleys to increase the mechanical advantage. What is the mechanical advantage of this system? (1) 1 (2) 2 (3) 3 (4) 4

31. Suppose the lower pulley was removed so that the object was supported only by the upper pulley. What would the mechanical advantage be? (1) 1 (2) 2 (3) 3 (4) 0

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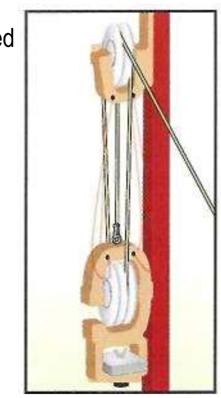
32. You use a rope and pulley system with a mechanical advantage of 5. How big an output load can you lift with an input force of 200 N? (1) 0.25 N (2) 40 N (3) 1,000 N (4) 195 N

33. The input force on the rope and pulley pictured to the right is 2 N. What is the output force?



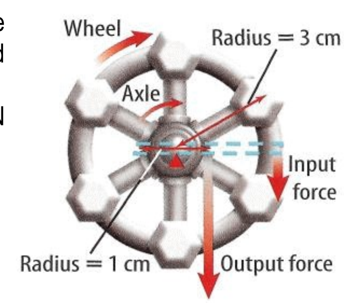
(1) 2N

(2) 4N

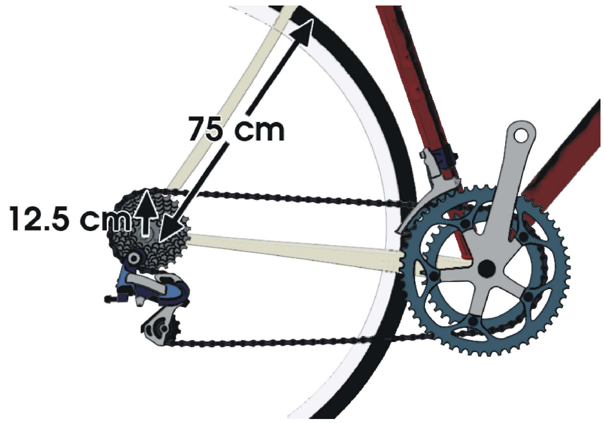
(3) 6N

(4) 8N

34. What is the output force if the input force on the wheel pictured to the right is 100 N? (1) 3 N (2) 100 N (3) 300 N (4) 1,000 N



Answer questions 35-36 by referring to the diagram of the bicycle wheel below.

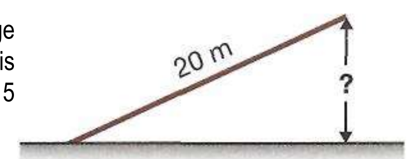


35. When the rider pedals, the mechanical advantage is (1) 6 (2) 62.5 (3) 0.167 (4) 87.5

36. The rider presses down on the pedal with a force of 720 N. What force does the wheel transfer to the road? (1) 720 N (2) 120 N (3) 4,320 N (4) 87.5 N

37. What is the mechanical advantage of a 6-m long ramp that extends from a ground-level sidewalk to a 2-m high porch? (1) 1 (2) 2 (3) 3 (4) 4

38. The mechanical advantage of the ramp is 10. What is the height? (1) 2 m (2) 5 m (3) 10 m (4) 20 m



Answers

1. 2	**9.** 2	**17.** 1	**25.** 1	**33.** 3
2. 4	**10.** 2	**18.** 3	**26.** 2	**34.** 3
3. 3	**11.** 1	**19.** 3	**27.** 3	**35.** 3
4. 1	**12.** 3	**20.** 2	**28.** 2	**36.** 2
5. 1	**13.** 4	**21.** 3	**29.** 1	**37.** 3
6. 2	**14.** 1	**22.** 1	**30.** 2	**38.** 1
7. 1	**15.** 3	**23.** 1	**31.** 1	
8. 2	**16.** 2	**24.** 3	**32.** 3	