Work and Power

1. Work – When a ________________ causes an object to ________________ work is done

2. Work = Force X ________________ or W = ________________

3. If the object does not ________________ then no work is done. \( W = F \times d \) if \( d = \) ______ any number times 0 is 0 so ________________

4. Work also depends on ________________ - The force has to be in the ________________ direction as the motion or no work is done on the object. – Lifting the Books – Work ________________ done – Carrying the Books – Work ________________ done

5. The SI Unit for work is ________________ (J) \( F = N \) \( d = m \) so \( W = \) ______

   \[ 1 \text{J} = 1 \text{kg} \times \frac{1 \text{m}}{1 \text{s}^2} = 1 \text{J} \]

6. Work or Not Examples
   a. A scientist delivers a speech to an audience of his peers.
   b. A bodybuilder lifts 350 pounds above his head.
   c. A mother carries her baby from room to room.
   d. A father pushes a baby in a carriage.
   e. A woman carries a 20 kg grocery bag to her car?

7. ________________ is the transfer of ________________ through ________________ or ________________ exerted through a ________________

8. Work Examples
   a. Brett’s backpack weighs 30 N. How much work is done on the backpack when he lifts it 1.5 m from the floor to his back?

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   b. If it takes 375 J of work to push a box 75 m what is the force used to push the box?

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   c. A dancer lifts a 40 kg ballerina 1.4 m in the air and walks forward 2.2 m. How much work is done on the ballerina during and after the lift?

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9. __________________________ - The rate at which work is done. Remember that a rate is something that occurs over __________________________ or P = __________________________ The SI unit for Power is __________________________ (W)

10. Power = __________________________ / time or P = __________________________ The SI unit for Power is __________________________ (W)

11. A watt is the amount of power required to do _______________ of work in _______________.

12. So P = W/t  unit P = J/s  Watts = __________________________

13. Power examples

   a. How much power is used to do 375 J of work in 15 seconds?

      | Given | Equation | Solve |
      |-------|---------|-------|
      |       |         |       |

   b. If 25 W of power is used to do 450 J of work how long did it take to do the work?

      | Given | Equation | Solve |
      |-------|---------|-------|
      |       |         |       |

**Simple Machines**


15. by __________________________ the force that can be __________________________ to an object (car jack)

16. by __________________________ the ________________ over which the force can be applied (ramp)

17. by __________________________ the direction of the ________________ force (opening the blinds)

18. Lever a ________________ that is free to ________________ pivot about a ________________ or fulcrum

   a. __________________________ arm is where you apply your force.

   b. __________________________ arm is where the work is done.

   c. Ideal Mechanical Advantage (IMA) assumes a __________________________

   d. \( IMA = \frac{L_e}{L_r} = \frac{Effort\ arm\ length}{Resistance\ arm\ length} \)

   e. __________________________ must be greater than __________________________ in order to multiply the force.

f. First class lever

   i. The ________________ is in the middle

   ii. Changes ________________ of force. Examples: __________________________

19. Pulley: grooved __________________________ with a ________________ or chain running along the grove
a. equal to the number of ____________ segments if pulling ____________
b. Equal to one less than the number of rope segments minus 1 if pulling ____________
c. Fixed Pulley the IMA = ____________
   i. Does ____________ increase force
   ii. Changes ____________ direction of force
d. Movable Pulley the IMA = ____________
   i. ____________ force
   ii. ____________ change direction
e. Block & Tackle is a combination of ____________ and ____________ pulleys
   i. ____________ force (IMA = ____________)
   ii. May or may NOT ____________ direction
20. Wheel and Axle is ____________ wheels of ____________ sizes that rotate ____________
a. A pair of ____________ force is applied to ____________
b. ____________ moves less distance but with ____________
c. IMA = \( \frac{r_e}{r_r} = \frac{\text{effort radius}}{\text{resistance radius}} \)
d. IMA = \( \frac{l}{h} = \frac{\text{length}}{\text{height}} \)
21. Inclined plane is a ____________ used to raise objects
   a. IMA = \( \frac{l}{h} = \frac{\text{length}}{\text{height}} \)
22. Screw is a ____________ plane wrapped in a ____________ around a ____________
23. Wedge is a moving ____________ plane with 1 or 2 ____________
24. Zipper: ____________ lower wedges push teeth ____________, and ____________ upper wedge pushes teeth ____________
25. How do machines make work easier?
   a. ____________
   b. ____________
   c. ____________

Mechanical Advantage and Efficiency
26. ____________ machines is the combination of ____________ or more ____________ machines
27. Rube Goldberg Machine
28. Work In - ____________ force - F_e - The force applied ____________ the machine. Work In - W_in -
   The work done by ____________ on the machine.
29. Work Out - ____________ force - F_r - The force applied ____________ the machine to overcome resistance.
   Work out - W_out - The work done by the ____________
30. Ideal Machine - W_in = W_out - % energy transfer - There is no such thing as an ideal machine - you always
   some ____________ (through friction, air resistance, etc)
31. ____________ - a measure of how much of the ____________ put into a machine is changed
   into ____________ output work by the machine. (less heat from ____________)
32. efficiency = \( \frac{W_{\text{out}}}{W_{\text{in}}} \) x 100% - W_in is always ____________ than W_out
33. Mechanical Advantage - How much a machine ____________ force or distance.
   MA = output force (______) / input force (______) or MA = ____________ distance / ____________ distance
34. Lever - MA = Length of ____________ arm / Length of resistance arm
35. Inclined Plane - MA = ____________ distance / Resistance distance or Length of slope / ____________ of slope
36. Mechanical Advantage
37. The number of times a force exerted on a machine is multiplied by the machine
38. Mechanical advantage (MA) = \( \frac{\text{resistance force}}{\text{effort force}} \) or Mechanical advantage (MA) = \( \frac{\text{effort distance}}{\text{resistance distance}} \)
39. Mechanical Advantage Examples

a. What is the mechanical advantage of the following simple machine?

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b. Determine the mechanical advantage of an automobile jack that lifts a 9900 N car with an input force of 150 N.

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c. Calculate the mechanical advantage of a ramp that is 6.0 m long and 1.5 m high.

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d. A worker applies an effort force of 20 N to open a window with a resistance force of 500 N. What is the crowbar’s MA?

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e. Find the effort force needed to lift a 2000 N rock using a jack with a mechanical advantage of 10.

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f. What is the mechanical advantage of the following simple machine?

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40. Mechanical Advantage of pulleys is very easy
   a. Count the number of rope segments visible
      i. If rope is pulling down subtract 1
      ii. If rope is pulling up do nothing

41. Pulley Examples

![Systems of Pulleys]

42. ____________ is a measure of how completely ____________ is converted to ____________

   a. Efficiency = \( \frac{W_{out}}{W_{in}} \times 100 \)
   b. Always ____________ than 100% due to ____________

43. If a machine requires 26.0 J of work input to operate and produces 22.0 J of work output, what is its efficiency?

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