Energy Questions

Remember:
- Work = Force x Distance (Force in Newtons, Distance in meters, Work in Joules)
- KE = 1/2 x m x v^2 (mass in kilograms (kg), velocity in m/s, KE in Joules)
- PE = mgh (mass in kg, gravity = 9.8 m/s^2, height in meters, PE in Joules)
- Power = Work-done ÷ time interval (Work in Joules, time in seconds, Power in watts)

1. Calculate the work done when a 20 N force pushes a cart 3.5 m
   Knowns: \( F = 20 \text{ N} \)
   \( D = 3.5 \text{ m} \)
   Unknown: \( W \)
   Equation: \( W = F \cdot D \)
   Fill in #: \( W = 20 \cdot 3.5 \)
   Answer: (with units) \( W = 70 \text{ J} \)

2. Calculate the work done in lifting a 500 N barbell 2.2 m above the floor. What is the potential energy of the barbell when it is lifted to this height?
   Knowns: \( \text{Weight} = 500 \text{ N} \)
   \( h = 2.2 \text{ m} \)
   Unknown: \( PE = W \cdot h \)
   Equation: \( PE = 500 \text{ N} \cdot 2.2 \text{ m} \)
   Fill in #: \( PE = 1100 \text{ J} \)
   Answer: (with units) \( PE = 1100 \text{ J} \)

3. Calculate the power expended when the barbell in Question 2 is lifted 2.2 m in 2 seconds.
   Knowns: \( \text{Weight} = 500 \text{ N} \)
   \( \text{Height} = 2.2 \text{ m} \)
   \( T = 2 \text{ sec} \)
   Unknown: \( P, W \)
   Equation: \( W = F \cdot D \)
   \( PE = 500 \text{ N} \cdot 2.2 \text{ m} \)
   \( = 1100 \text{ J} \) (PE gained)
   Fill in #: \( P = W ÷ T \)
   \( = 1100 \text{ J} ÷ 2 \text{ sec} \)
   Answer: (with units) \( P = 550 \text{ watts} \)

4. Calculate the work needed to lift a 90 N block of ice a vertical distance of 3 m. What PE does it have?
   Knowns: \( W = F \cdot D \)
   \( = 90 \text{ N} \cdot 3 \text{ m} \)
   Unknown: \( PE = W \cdot h \)
   Equation: \( PE = 270 \text{ J} \)
   Fill in #: \( PE = \text{ PE gained} \)
   Answer: (with units)
5. Calculate the change in potential energy of 8 million kg of water dropping 50 m over Niagara Falls.
Knowns: Mass, Height
Unknown: \( \Delta P_E \)
Equation: \( P_E = m \cdot g \cdot H \)
Fill in #: \( P_E = 8,000,000 \text{ kg} \cdot 10 \text{ m/s}^2 \cdot 50 \text{ m} \)
Answer: \( P_E = 4 \text{ billion J} \)

6. If 8 million kg of water flows over Niagara Falls each second, calculate the power available at the bottom of the falls.
Knowns: Mass, Time (per sec), \( P_E \) (work)
Unknown: Power
Equation: \( P = \frac{\text{work}}{\text{time}} \)
Fill in #: \( P = \frac{4 \text{ billion J}}{1 \text{ sec}} \)
Answer: \( P = 4 \text{ billion W} \) (watts)

7. Calculate the kinetic energy of a 3 kg toy cart that moves at 4 m/s.
Knowns: \( KE = \frac{1}{2} m \cdot v^2 \)
Unknown: \( KE = \frac{1}{2} \cdot 3 \text{ kg} \cdot (4 \text{ m/s})^2 \)
Equation: \( KE = \frac{24 \text{ J}}{2} \)
Fill in #: \( KE = 24 \text{ J} \)
Answer: \( KE = 24 \text{ J} \)

8. Calculate the kinetic energy of the cart in Question 7 at twice the speed.
Knowns: \( KE = \frac{1}{2} m \cdot v^2 \)
Unknown: \( KE = \frac{1}{2} \cdot 3 \text{ kg} \cdot (8 \text{ m/s})^2 \)
Equation: \( KE = \frac{96 \text{ J}}{2} \)
Fill in #: \( KE = 96 \text{ J} \)
Answer: \( KE = 96 \text{ J} \)

9. Looking at questions 7 and 8, what happens to the energy when the speed is doubled?
It is quadrupled due to velocity being squared in the \( KE \) equation.

\( KE = \frac{1}{2} m \cdot v^2 \)

10. How much work is done on a 100 N boulder that you hold while standing still for 4 hours?
Knowns: \( W = F \cdot D \cdot R \)
Unknown: \( W \)
Equation: \( W = F \cdot D \)
Fill in #: \( W = 100 \text{ N} \cdot 4 \text{ m} \)
Answer: \( W = 400 \)
11. State two reasons why a rock projected with a slingshot will go faster if the rubber is stretched further.

- Gain in PE through the work done: $W = F \cdot D$
- More work is done (greater force required to stretch & it is stretched a greater distance)

12. If a mouse and an elephant both run with the same kinetic energy, can you say which is running faster? Explain in terms of the equation for KE.

$$KE = \frac{1}{2} \cdot M \cdot V^2$$

- **Mouse**
- **Elephant**

13. An astronaut in full space gear climbs a vertical ladder on the earth. Later, the astronaut makes the same climb on the moon. In which location does the gravitational potential energy of the astronaut change more? Explain using the equation for Potential Energy.

$$PE = \text{Weight} \cdot \text{Height}$$

- Less weight on moon so less PE gained.
- - More weight causes greater change in PE

[Earth]

14. Most earth satellites follow an oval-shaped path rather than a circular path around the earth. The PE increases when the satellite moves farther from the earth. According to the law of energy conservation, does the satellite have its greatest speed when it is closest to or farthest from the earth? Why?

- PE transfers to KE most closest to Earth.
- The point with the least PE would have the greatest KE since the energy is transferred.

15. Why does a small, lightweight, car generally have better fuel economy than a big, heavy car? How does a streamlined design improve fuel economy?

$$KE = \frac{1}{2} \cdot M \cdot V^2$$

- Lower mass allows a greater velocity to have the same KE as the larger car.

16. Does using an automobile's air conditioner while driving increase fuel consumption? What about driving with the lights on? What about playing the car radio when parked with the engine off? Explain in terms of conservation of energy.

- Yes it does. It takes energy to power the air conditioner that ultimately comes from the stored energy in the gasoline. The gas will need to be used to recharge the battery to replace the energy used.

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Hammer falls off a rooftop and strikes the ground with a certain KE. If it fell from a roof that was four times higher, how many times more would its KE at impact be? How much larger would its speed at impact be?

Draw a picture of the hammer on each of the roofs:

$$ PE = W \cdot D $$

4 times $\Rightarrow$ PE is increased by 4x & transfers to KE making it 4x as well.

16. A certain car can go from 0 to 100 km/h in 10 seconds. If the engine delivered twice the power to the wheels, how many seconds would it take?

$$ P = \frac{W}{t} $$ or $$ P = \frac{W}{\frac{1}{2}t} $$

*Some work done in $\frac{1}{2}$ the time will double the power.

17. If a car traveling at 60 km/h will skid 20 m when its brakes lock, how far will it skid if it is traveling at 120 km/h when its brakes lock? Assume that skid distance is directly proportional to its kinetic energy when the brakes are applied.

$$ KE = \frac{1}{2}mv^2 $$

*Doubling velocity increases KE by 4 times since velocity is squared.

Distance = 20m x 4 = 80m

18. What is the potential energy of a 50 kg boulder sitting on a 100 m cliff?

Knowns: $H = 100$ meters $W = 500N$

Unknown: $PE$

Equation: $PE = W \cdot H$

Fill in #: $= 500N \cdot 100m$

Answer: $= 50000J$ (with units)

19. What is the kinetic energy of a 40 kg boulder that falls from a 200 m cliff just before it hits the ground? Assume no air resistance.

Knowns: All PE $\Rightarrow$ KE at bottom

Unknown: $W = 400 N$

Equation: $PE = W \cdot H$

Fill in #: $= 400N \cdot 200m$

Answer: $PE = 80000J$ (at top)

Answer: $KE = 80000J$ (at bottom)