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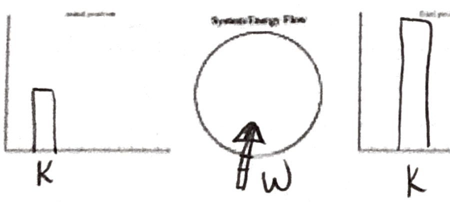
MasteringPhysics 4.1 - Intro to Energy

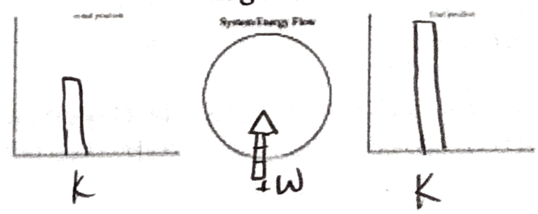
1. Two blocks of ice, one four times as heavy as the other, are at rest on a frozen lake. A person pushes each block the same distance d. Ignore friction and assume that an equal force F is exerted on each block.

Solve using only variables, then substitute relevant values.

Smaller Block



Big Block



Conservation of Energy Equations:

a. Which of the following statements is true about the kinetic energy of the heavier block after the push?

- It is smaller than the kinetic energy of the lighter block.
- (It is equal to the kinetic energy of the lighter block.)
- It is larger than the kinetic energy of the lighter block.
- It cannot be determined without knowing the force and the mass of each block.

$W = F_{\parallel} \cdot d$

Force and distance are equal so Work is equal

$W_{total} = \Delta K$ so K is the same

b. Compared to the speed of the heavier block, what is the speed of the light block after both blocks move the same distance d?

- one quarter as fast
- half as fast
- the same speed
- (twice as fast)
- four times as fast

$K_E = \frac{1}{2} m v^2$

$\frac{1}{2} m_h (v_h)^2 = \frac{1}{2} m_l (V_l)^2$

$m_h = 4 m_l$

$\frac{1}{2}(4 m_l)(V_h^2) = \frac{1}{2} m_l (V_l)^2$

$\sqrt{(V_l^2) = 4 (V_h^2)}$

$V_l = 2 V_h$

c. Now assume that both blocks have the same speed after being pushed with the same force F. What can be said about the distances the two blocks are pushed?

- The heavy block must be pushed 16 times farther than the light block.
- (The heavy block must be pushed 4 times farther than the light block.)
- The heavy block must be pushed 2 times farther than the light block.
- The heavy block must be pushed the same distance as the light block.
- The heavy block must be pushed half as far as the light block.

$\frac{W_h}{W_l} = 4$

$K_h = \frac{1}{2} 4 m_l v^2 \quad K_l = \frac{1}{2} m_l v^2$

$v^2 = \frac{2 K_h}{4 m_l}$

$\frac{2K_h}{4m_l} = \frac{2K_l}{m_l}$

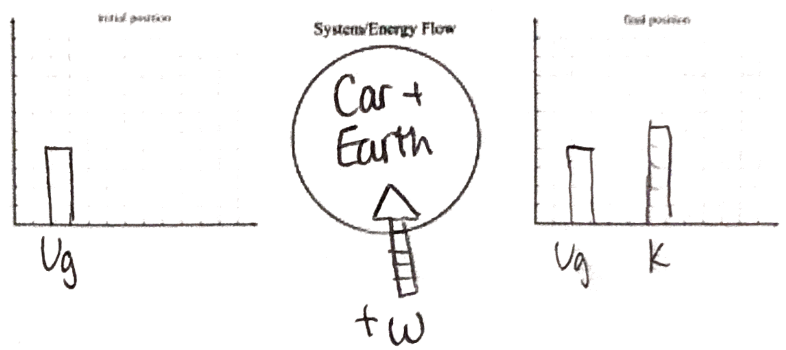
$2 K_h m_l = 2 K_l 4 m_l$

$K_h = 4 K_l$

$\frac{K_h}{K_l} = 4$

2. In Testing Experiment Table 7.3, and the associated video below, it is seen that in an isolated system, the energy of a system is constant. The definition of an isolated system is such that the interactions with the environment can be neglected. In other words, external objects do zero work on the system.

a. Consider the same experimental set up of a cart rolling down two ramps with different slopes. This time the system is just the cart and not the Earth. Can this still be considered an isolated system?



- Yes because it is the same situation as before and choice of system does not affect the outcome.
- Yes because the Earth does no work on the cart.
- No because the Earth does work on the cart. → U_g

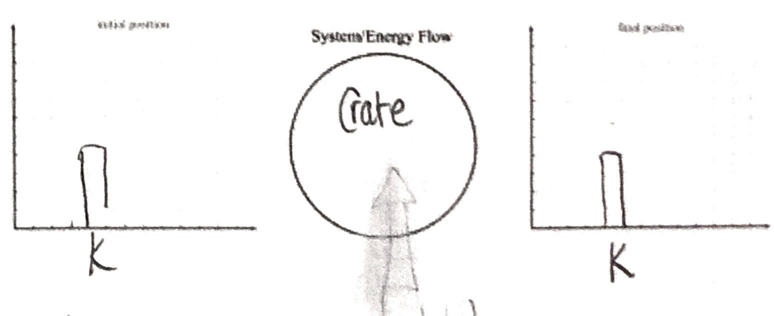
b. What happens to the total energy of the system (again, cart only) as the cart goes from its starting point to the bottom of the ramp?

- It increases, because the force exerted by Earth on the cart is now doing positive work but it is different amounts for the two choices of ramp.
- It increases, because the force exerted by Earth on the cart is now doing positive work and it is the same amount for the two choices of ramp. (Height is the same)
- It increases the same for each ramp, but the kinetic energy is a different amount compared to when Earth was in the system because now there is both gravitational work and gravitational potential energy.
- It stays the same because the kinetic energy is still the same regardless of the choice of system.
- It decreases because the cart's final location is lower than its initial location for both ramps.

c. The cart and Earth are considered an isolated system. The ramp did not need to be included in the system for this to be isolated. The reason for this is:

- the ramp doesn't exert a force.
- the ramp does exert a force but it does no work. (Not in the direction of displacement (perpendicular))
- the ramp does exert a force but there are canceling forces because of Newton's 3rd Law.

3. A person applies a 50 N force on a crate, causing it to move horizontally at a constant speed through a distance of 10 m. What is the net work done on the crate?



- The net work done on the crate is 0.2 J.
- The net work done on the crate is 500 J.
- The net work done on the crate is zero joules.
- The net work done on the crate is 250 J.
- The net work done on the crate is 5 J.

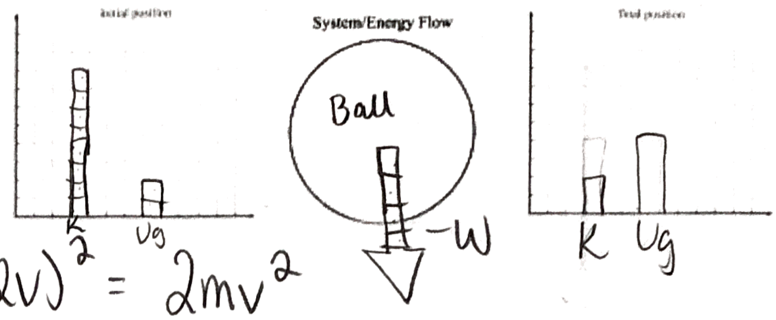
$W = F \cdot \Delta x$

Constant speed = Constant K_E = No W

14. Energy is a conserved quantity, meaning that…

If no work is done on the system, the energy of the system will not change

15. Two identical balls are thrown vertically upward. The second ball is thrown with an initial speed that is twice that of the first ball. How does the maximum height of the two balls compare?
Try to use only variables to answer this question. You should be able to prove it to yourself.



$K_{E_1} = \frac{1}{2}mv^2$ $\quad K_{E_2} = \frac{1}{2}m(2v)^2 = 2mv^2$

$\frac{K_{E_2}}{K_{E_1}} = \frac{2mv^2}{\frac{1}{2}mv^2} = 4$ so $\frac{W_{E_2}}{W_{E_1}} = 4$ and $\frac{d_{E_2}}{d_{E_1}} = 4$

Maximum height of the second ball is four times that of the first ball

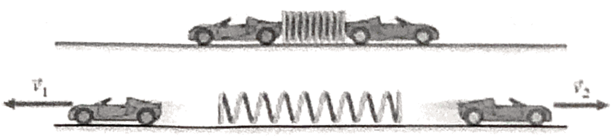
16. Which of the following statements is/are true?

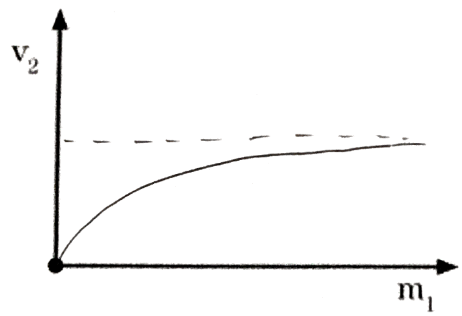
- [x] The total mechanical energy of a system is constant only if conservative forces act. → stuff in the system
- [ ] The total mechanical energy of a system, at any one instant, is either all kinetic or all potential energy.
- [ ] The total mechanical energy of a system is equally divided between kinetic and potential energy.
- [x] Mechanical energy can be dissipated to nonmechanical forms of energy. → U_{int} and anything that isn't potential / kinetic
- [ ] The total mechanical energy of a system is constant only if nonconservative forces act.

17. Which of the following statements is/are true?

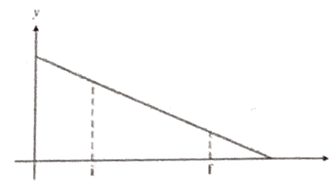
- [x] A potential energy function can be specified for a conservative force. U_g or E_{El}
- [ ] A potential energy function can be specified for a nonconservative force.
- [x] A conservative force permits a two-way conversion between kinetic and potential energies.
- [ ] A nonconservative force permits a two-way conversion between kinetic and potential energies.
- [x] The work done by a nonconservative force depends on the path taken. Parallel to displacement
- [ ] The work done by a conservative force depends on the path taken.

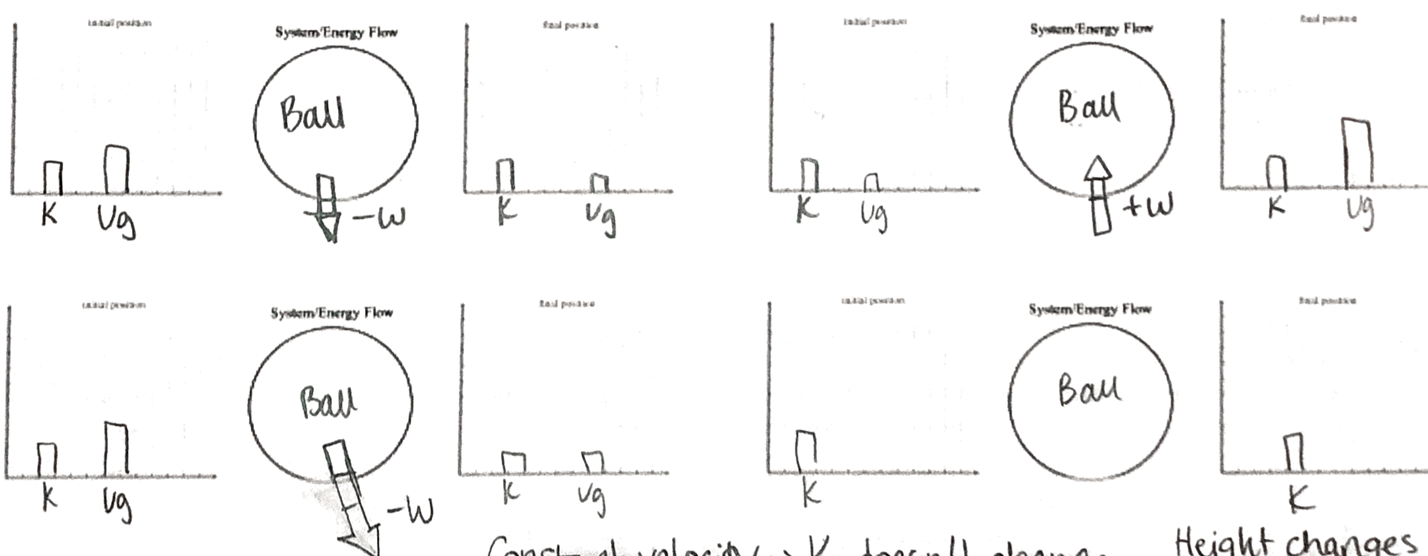
8. You place two toy cars on a horizontal table and connect them with a light compressed spring as shown in (Figure 1). The spring tries to push the cars apart, but they are tied together by a thread. When the thread is burned, the spring pushes the cars apart. You decide to investigate how the final speed of car 2 depends on the mass of car 1. You run several experiments changing m1 and measuring v2 while keeping the compression of the spring and the mass of car 2 constant. Which of the v2-versus-m1 graphs do you expect to obtain? Evaluate the graphs by analyzing limiting cases.





9. The graph in (Figure 1) shows the time dependence of the vertical displacement of a lead ball with marked initial and final states. Sketch the possible LOL charts below:





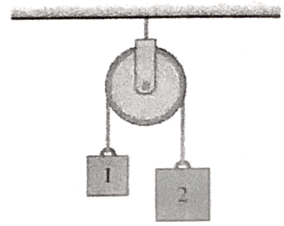
Constant velocity → Ke doesn't change

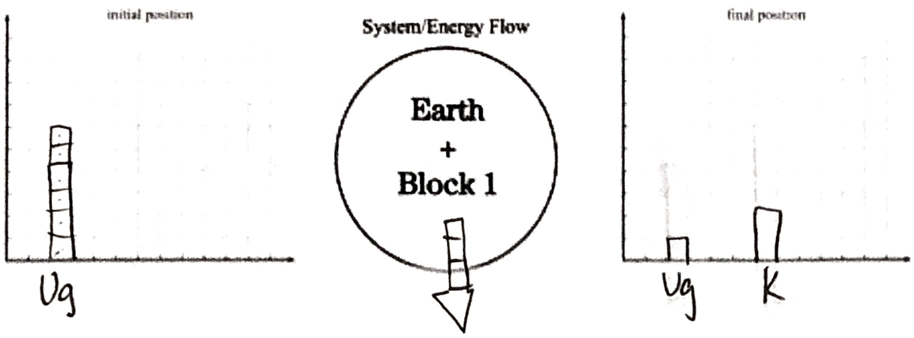
Height changes so Ug changes

10. Which force(s) from the examples described below do(es) zero work on the respective system(s)?

- [ ] A person pulls a sled uphill. Consider the force the person exerts on the sled.
- [x] A rope supports a swinging chandelier. Consider the force the rope exerts on the chandelier Not in direction of displacement
- [x] A person pushes a car stuck in the snow but the car does not move. Consider the force the person exerts on the car. Not moving
- [x] A person uses a self-propelled lawn mower (riding mower) on a level lawn. Consider the force the person exerts on the lawn mower.
- [x] A person holds a child. Consider the force the person exerts on the child.

11. What happens to the energy of the block 1-Earth system as the blocks are released and block 1 moves downward?

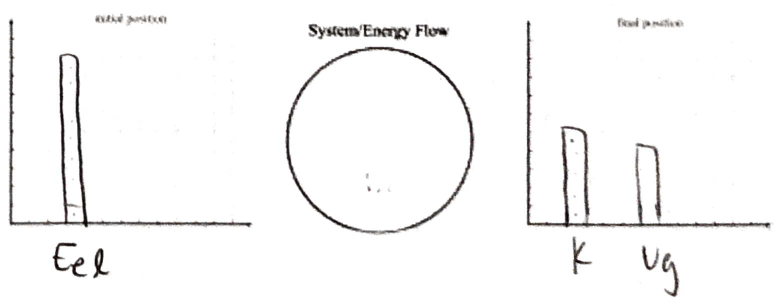




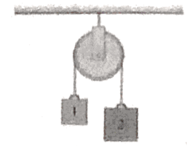
- o The energy decreases.
- o The energy increases.
- o The energy stays constant.
- o It's impossible to say without including block 2 in the system.

12. In which of the following is positive work done by a person on a suitcase?
- o The person holds a heavy suitcase.
- o The person lifts a heavy suitcase. same direction as motion
- o The person stands on a moving walkway carrying a heavy suitcase.
- o All of the above
- o None of the above

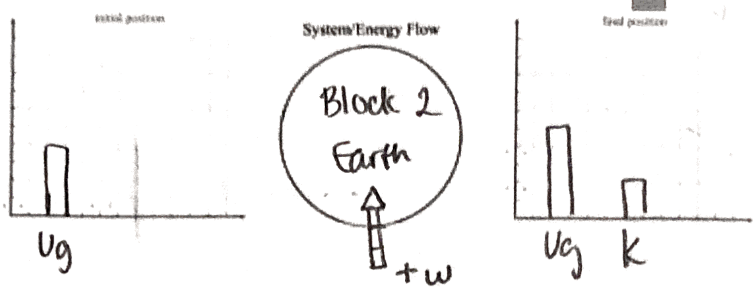
13. Which answer best represents the system's change in energy for the following process? The system includes Earth, two carts, and a compressed spring between the carts. The spring is released, and in the final state, one cart is moving up a frictionless ramp until it stops. The other cart is moving in the opposite direction on a horizontal frictionless track.
- o Elastic potential energy to kinetic energy
- o Elastic potential energy to gravitational potential energy
- o Elastic potential energy to kinetic energy and gravitational potential energy
- o Kinetic energy to gravitational potential energy



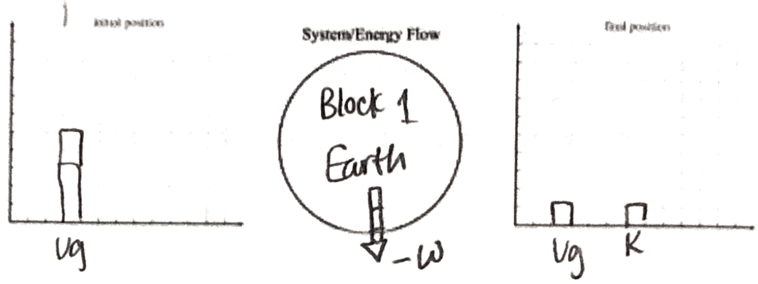
14. When the blocks of the Atwood machine shown in (Figure 1) are released, block 1 moves downward.



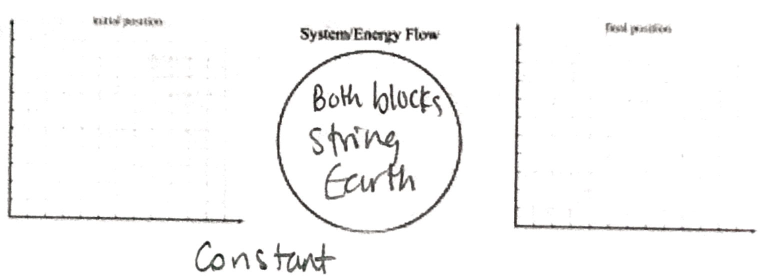
a. Choose the correct energy analysis for the system of block 2 and Earth.
- The total energy of the system decreases.
- The total energy of the system stays constant.
- The total energy of the system increases.
- There isn't enough data to predict the behavior of the total energy of the system.



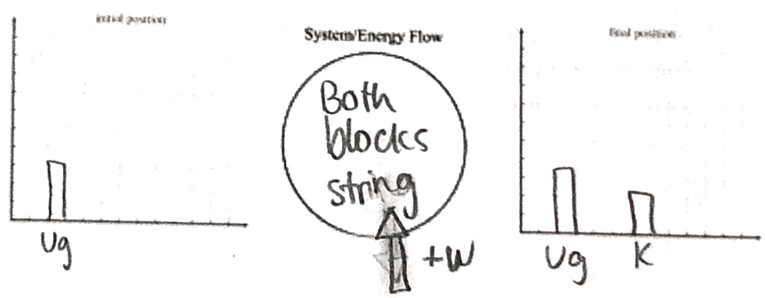
b. Choose the correct energy analysis for the system of block 1 and Earth.
- The total energy of the system stays constant.
- The total energy of the system decreases.
- The total energy of the system increases.
- There isn't enough data to predict the behavior of the total energy of the system.



c. Choose the correct energy analysis for the system of both blocks, the string, and Earth.
- The total energy of the system decreases.
- The total energy of the system increases.
- The total energy of the system stays constant.
- There isn't enough data to predict the behavior of the total energy of the system.



d. Choose the correct energy analysis for the system of both blocks and the string.
- The total energy of the system stays constant.
- The total energy of the system decreases.
- The total energy of the system increases.
- There isn't enough data to predict the behavior of the total energy of the system.

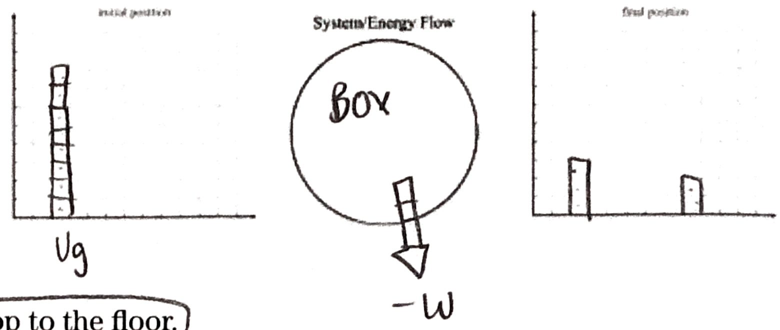


15. Three processes are described below. Choose one process in which there is work done on the system. The spring, Earth, and the cart are part of the system.
- A cart at the top of a smooth inclined surface slides at increasing speed to the bottom where it runs into and compresses a spring (ignore friction).
- A cart at the top of a smooth inclined surface coasts at increasing speed to the bottom (ignore friction).
- A relaxed spring rests upright on a tabletop. You slowly compress the spring. You then release the spring and it flies up several meters to its highest point.

$E_{el} + W = K$ (hand pushes the spring)

16. Choose which statement describes a process in which an external force does negative work on the system. The person is not part of the system.

- ○ A person carries a bag of groceries horizontally from one location to another.
- ○ A person slowly lifts a box from the floor to a tabletop.
- ○ A person holds a heavy suitcase.
- ○ A person slowly lowers a box from a tabletop to the floor.



17. Why does the Moon have no atmosphere, but Earth does?

Total energy should be negative for a molecule to stay near Earth
Large K_E ⇒ total energy becomes positive and molecules fly away
GPE is smaller on the moon so total energy for molecule-moon is positive

18. Your friend thinks that the escape speed should be greater for more massive objects than for less massive objects. Provide an argument for his opinion. Then provide a counterargument for why the escape speed is independent of the mass of the object.

More massive objects require greater changes of potential energy + greater initial K_E
K_E is proportional to the mass and the square of the speed

19. What will happen to Earth if our Sun becomes a black hole (with the same mass)?

- ❑ Earth will fall on Sun.
- ❑ Earth will be freezing in the absence of a heat source. No more radiation
- ❑ The Earth's orbit will change. But same gravitational force
- ❑ Nothing will happen.

20. What is energy?

- ○ A physical quantity
- ○ A model
- ○ A physical phenomenon
- ○ None of these

21. How can satellites stay in orbit without any jet propulsion system? Choose the correct explanation.

Gravitational force is perpendicular to the direction of the velocity, so no work is done and kinetic energy stays the same

22. You push a small cart by exerting a constant force F along a table. After you push the cart a distance s, the cart falls off the table and lands on the floor a distance D_1 away from the table edge. You repeat the same experiment (same F, same s) using a heavier cart and obtain a new distance D_2. Choose the answer that correctly compares the distances D_1 and D_2 and gives the best explanation of the outcome.

- ✗ $D_1 = D_2$ because the same work was done on both carts before they flew off the table.
- ○ $D_1 > D_2$ because the carts had the same kinetic energy before they flew off the table, and consequently the speed of the lighter cart had been greater.
- ○ $D_1 > D_2$ because the kinetic energy of cart 1 had been greater than that of cart 2 before they flew off the table.
- ○ $D_1 = D_2$ because the carts had the same momentum before they flew off the table.

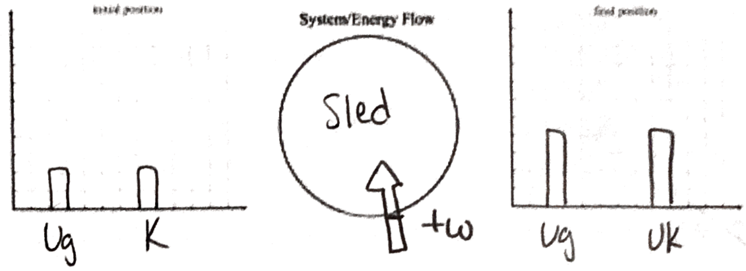
$K_E = \frac{1}{2}mv^2 = W$
Same Force, same distance, same work

23. You use a rope to slowly pull a sled and its passenger 55 m up a 20° incline, exerting a 160 N force on the rope. **The system is the sled**.

a. How much work will you do if you pull parallel to the incline?

Solve using only variables, then substitute relevant values.

Parallel to the incline → all of the force is work



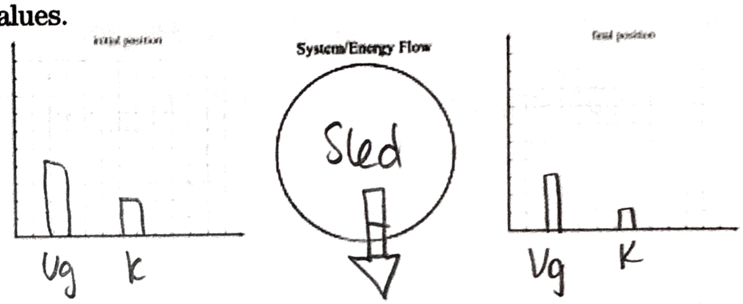
$W = F \cdot \Delta x$

$W = 160\,N \cdot 55\,m = 8800\,J$

b. How much work will you do if you exert the same magnitude force while slowly lowering the sled back down the incline and pulling parallel to the incline?

Solve using only variables, then substitute relevant values.

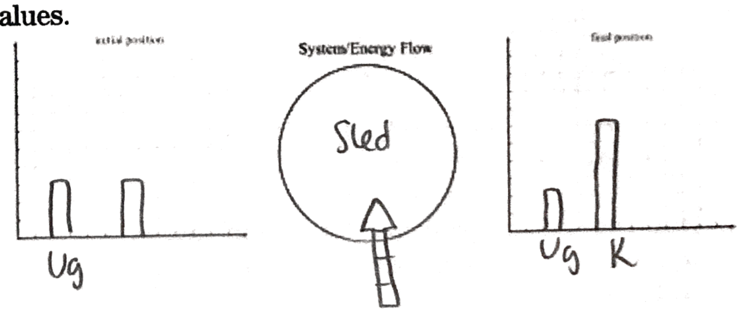
Parallel to the incline but in the opposite direction



$W = -8800\,J$

c. How much work did Earth do on the sled for the trip in Part B?

Solve using only variables, then substitute relevant values.



$W_{Earth\ on\ sled} = 8800\,J$