Course and Section_______ Names ___________________________

Date___________________ ___________________________

WORK-ENERGY SIMULATION

Introduction

The work done by a constant force acting on an object is

$$W = \vec{F} \Delta \vec{x}$$

where Δx is the displacement of the object.
The kinetic energy of an object of mass *M* moving at velocity *v* is

$$KE = \frac{1}{2} M v^2$$

The work-kinetic energy theorem says that the new work done by the net force acting on an object is equal the change of the kinetic energy of the object.

$$W = \Delta KE = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

The gravitational potential energy of an object of mass *M* and at distance *h* from the ground is

$$PE = Mgh$$

Use $g = 9.81$ m/sec^2.
The conservation of energy states that the energy cannot be created or destroyed but may change from one form to another.

Submit your answers using Blackboard.

1 – Preliminary Questions

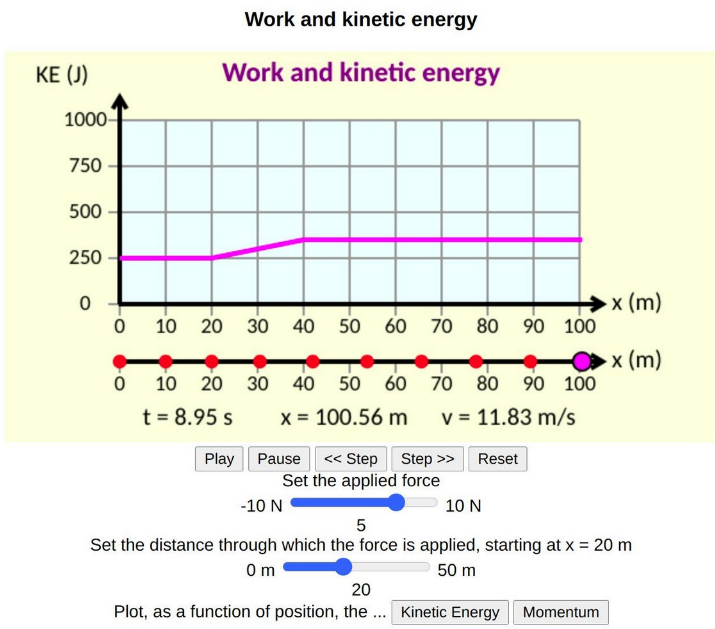
1. You have two carts, one which is empty and has mass *m*. The second cart is of the same mass but loaded with twice the mass of the empty cart i.e. it has mass 3*m*. You push each of them (one at a time) with the same constant force, over the same distance, starting from rest. After you have pushed them through this distance, you remove the force. How will the kinetic energy of the loaded and empty carts compare to each other?

2. In the same experiment as in the previous question, how will the speed of the loaded and empty carts compare to each other?
3. In the previous question suppose the speed of the empty cart is v_e and the speed of the loaded cart is v. How is v_e related to v?

4. What is 1 Joule of work?

2 – Work and ΔKE

Run the following simulation.
https://pages.physics.ua.edu/lab10x/1mech/SIM/applet/Sim_Work_Energy.html



Note that the force is applied starting at x = 20 m.
5. Before the force is applied the KE is 250 J. What is the mass of the objects?

Set the applied force to 10 N and to act over a distance of 50 m.
6. What is the final kinetic energy?
7.What is the change in kinetic energy?
8. Find the work done by the force.

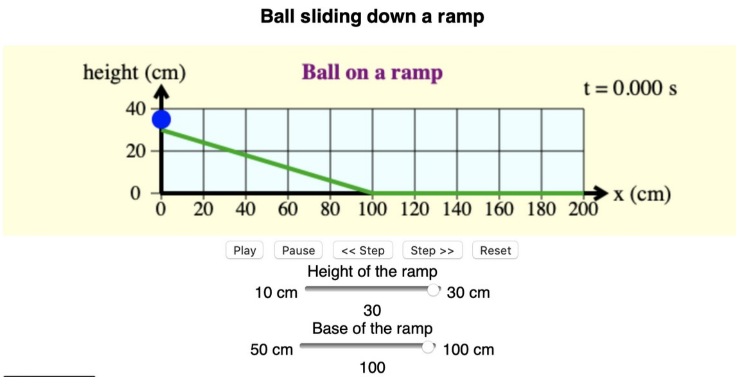
Set the applied force to 4 N and to act over a distance of 40 m.
9. What is the final kinetic energy?
10. What is the change in kinetic energy?
11. Find the work done by the force.

Suppose the force acting on the object is friction
12. How will the final kinetic energy compare to the initial kinetic energy?
To simulate friction set the applied force to -2 N (note the negative sign). Set the friction to act over a distance of 20 m.
13. What is the final kinetic energy?
14. What is the change in the kinetic energy?
15. What is the work done by the friction?

Set the friction to act over a distance of 50 m.
16. What is the minimum magnitude of friction necessary to bring the object to a stop?

3 – Ball Sliding Down a Ramp

Open the following simulation (http://physics.bu.edu/~duffy/HTML5/ramp.html)



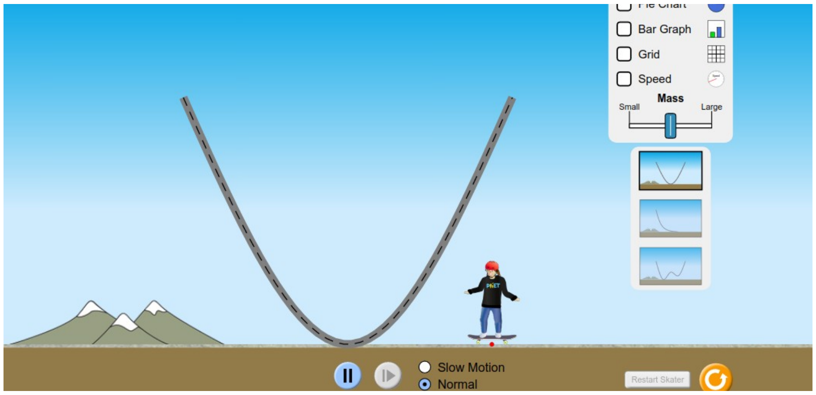
The *Play* button runs the simulation. You can click on S*tep* to analyze the data on each point. Assume the mass of the ball is 500 g. And the ramp is frictionless.

Set the height of the ramp to 20 cm and base of the ramp to 100 cm.
17. What is the initial potential energy?
18. What is the initial kinetic energy?
19. What is the potential energy at the bottom of the ramp?
20. What is the kinetic energy at the bottom of the ramp?
21. Find the velocity at the bottom of the ramp.
22. Now reduce the length of the base, what happens to the time taken to reach the ground?

Set the height to 30 cm and the length of the base the 80 cm.
23. Calculate the time it takes for the ball to reach the ground. Use the simulation to verify your calculation.

4 – Skater and Energy Conservation

Click the following link and run the simulation.
(https://phet.colorado.edu/en/simulation/energy-skate-park-basics)



Choose *Intro.* Check the *Grid* and S*peed* and the *Bar Graph*. Now choose the mass small. Place the skater on the ramp at 4 m above the ground and then let him start move downward.
24. At which point of the track is the velocity of the skater is maximum?
25. At which point of the track is the velocity of the skater is minimum?
26. At which point of the track is the kinetic energy of the skater is maximum?
27. At which point of the track is the potential energy of the skater is minimum?
28. As the kinetic energy increases what happens to the potential energy?
29. How does the total energy change as the skater oscillates in the ramp?
30. Will the skater in the simulation ever come to a stop?

Restart, but now place the skater on the ramp at 6 m above the ground
31. How does his max speed compare to the max speed in the previous problem?
32. How does the total energy compare to the total energy in the previous problem?

Restart, skater on the ramp at 6 m above the ground but now change the mass to 'Large'.
33. How does the max kinetic energy compare to the previous max kinetic energy?
34. How does the max potential energy compare to the previous max potential energy?
35. How does the max speed compares to the previous max speed?

Restart the simulation and Choose *Friction* (look at the bottom). Check the *Grid* and S*peed* and the *Bar Graph*. Now choose the mass Large. Keep friction in the middle value. Place the skater on the ramp at 6 m above the ground and then let him start move downward.
36. What happens to the thermal energy?
37. What is the final value of the potential energy?
38. What is the final value of the kinetic energy?
39. The final value of the thermal energy is equal to which energy?