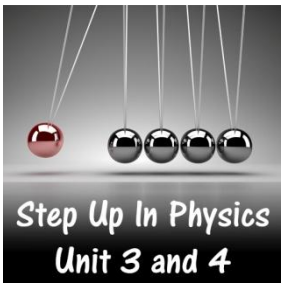
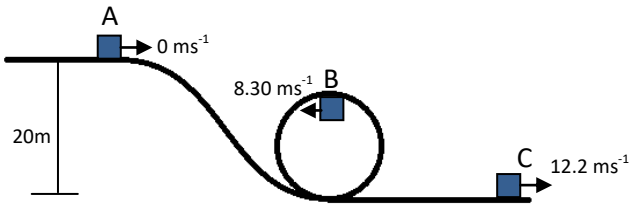
Work and Energy in a Gravitational Field

Problems Worksheet



1. The vertical loop of the rollercoaster track shown below has a radius of 4.50 m. The speed of the 150 kg rollercoaster is shown at location A, B, and C. Frictional forces on the track are significant.
   a. For each location determine the:
      i. kinetic energy and
      ii. potential energy

      of the rollercoaster.



   b. Why does the rollercoaster have less energy at C than at A?

2. Describe a situation when work is done **against** a gravitational field and when work is done **by** a gravitational field.

3. Calculate the potential energy gained as a 3.00 kg object is raised from a position 5.00 m above the ground to a position 12.0 m above the ground.

4. Calculate the work done by a waiter who displaces a 2.80 kg tray of glasses horizontally by 15.0 m.

5. 325 J of work was used to raise a 2.50 kg object above its starting position.
    a. Calculate the height the object was raised.

    b. Calculate the speed of the object when it had fallen half way back towards its starting position.

    c. Calculate the height the object when it has half of the speed it would gain just prior to reaching its starting position.

6. Starting from $W = Fs$ and giving detailed explanation of the variables and substitutions used, show that $W = mg\Delta h$ for an object falling through a gravitational field.

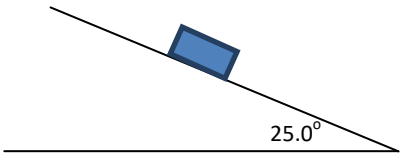
7. A weightlifter steadily raises a 160 kg barbell vertically by 80.0 cm over 2.80 s.
    a. Calculate the amount of work done against the gravitational field.

    b. Calculate the kinetic energy of the barbell.

    c. Calculate the work done by the weightlifter.

Question 8 assumes prior knowledge of the motion of objects down inclined planes.

8. An 8.00 kg box, starting from rest, slides down a 3.50 m long ramp as shown in the diagram below. The box is moving at 4.80 ms^{-1} when it reaches the base of the ramp. Frictional forces are significant as it slides.



    a. Calculate the change in potential energy of the box between the top and bottom of the ramp.

    b. Calculate the work done on the box by the frictional forces between the box and the ramp.

c. Determine the magnitude of the average frictional force acting on the box.

d. What **two** transformations of energy occur as the box slides down the ramp?

Question 9 assumes prior knowledge of the motion of projectiles.

9. A 45.0 g golf ball is whacked at an initial velocity of 26.0 ms^{-1} and reaches a peak height of 22.5 m above its starting height before landing in a water hazard 1.50 m below its starting height. Treat the starting position of the ball as the zero for gravitational potential energy.

It is possible to solve some parts of this problem with equations of motion. However, try to solve them using the concepts of work and energy.

a. Calculate the kinetic energy of the ball at its initial position

b. Calculate the ball's maximum potential energy.

c. Calculate the ball's horizontal velocity.

d. Calculate the velocity of the ball as it lands in the water hazard.

10. A 75.0 kg sky diver jumps out of a plane soaring at an altitude of 2.50 km at a speed of 120 kmh^{-1}. Due to the high speeds, air resistance is a significant factor. The terminal velocity of the sky diver is 180 kmh^{-1} which is reached after falling to an altitude of 1.80 km. After this point the sky diver's speed does not change until the parachute is opened.
    a. Calculate the work done by the gravitational field on the skydiver as he reaches an altitude of 1.80 km.

    b. Calculate the kinetic energy of the skydiver when he reaches an altitude of 1.80 km.

    c. Calculate the work done by air resistance during the descent of the sky diver from the plane to an altitude of 1.80 km.

d. The sky diver opens his parachute at an altitude of 800 m. He falls vertically and hits the ground at 16.0 ms^{-1}. Calculate the magnitude of the average air resistance which slowed his descent while the parachute was open.