EP0605 Tutorial 5 – Work, Energy and Power

1. You push your physics book 1.50 m along a horizontal table-top with a horizontal push of 2.40 N while the opposing force of friction is 0.600 N. How much work does each of the following forces do on the book:
   (a) your 2.40-N push,
   (b) the friction force,
   (c) the normal force from the table-top,
   (d) the force of gravity,
   (e) What is the net work done on the book?

2. A 75.0-kg painter climbs a ladder that is 2.75 m long leaning against a vertical wall. The ladder makes a 30.0° angle with the wall.
   (a) How much work does gravity do on the painter?
   (b) Does the answer to part (a) depend on whether the painter climbs at constant speed or accelerates up the ladder? Why?

3. You apply a constant force $\boldsymbol{F}$ = (-68.0 N) **i** + (36.0 N) **j** to a 380-kg car as the car travels 48.0 m in a direction that is 240° counter clockwise from the +*x*-axis. How much work does the force you apply do on the car?

4. An object is pushed up an incline of constant slope angle α so that it reaches the top of the incline which is at a vertical distance *h* from the bottom of the incline. The incline is slippery but there is some friction present with kinetic friction coefficient μ_k. Using work-energy theorem, calculate the minimum speed you must give the object at the bottom of the incline so that it will reach the top. Express your answer in terms of *g*, *h*, μ_k, and α.

5. A 30.0-kg crate is initially moving with a velocity that has magnitude 3.90 m/s in a direction 37.0° west of north. How much work must be done on the crate to change its velocity to 5.62 m/s in a direction 63.0° south of east?

6. A force in the +*x*-direction with magnitude $F(x)$ = [18.0 N – (0.530 N/m) *x*] is applied to a 6.00-kg box that is sitting on the horizontal, frictionless surface of a frozen lake. $F(x)$ is the only horizontal force on the box. If the box is initially at rest at $x = 0$, what is its speed after it has travelled 14.0 m?

7. An elevator has mass 600 kg, not including passengers. The elevator is designed to ascend, at constant speed, a vertical displacement of 20.0 m (five floors) in 16.0 s. It is driven by a motor that can provide up to 40 hp to the elevator. What is the maximum number of passengers possible in the elevator? You can assume the mass of an average passenger to be 65 kg and 1 hp = 746 W.

8. A force $\boldsymbol{F} = -(\alpha x^2)\,\mathbf{i}$ acts on an object where α is numerically equal to 12. The SI unit of force is newton while 'x' is in metres.
   (a) What is the SI unit of α?
   (b) What is the work done by the force if the object moves along a straight line from (0.10 m,0) to (0.30 m,0)?
   (c) What is the work done from (0.30 m, 0) to (0.10 m, 0)?
   (d) Is the force conservative? Why? If Yes, find the potential energy function $U(x)$ assuming $U = 0$ when $x = 0$.

9. A crate of mass M starts from rest at the top of a frictionless ramp inclined at an angle α above the horizontal. Find its speed at the bottom of the ramp, a distance d from where it started. Do this in two ways:

   (a) Take the level at which the potential energy is zero to be at the bottom of the ramp with y positive upward.
   (b) Take the zero level for the potential to be at the top of the ramp with y positive upward.
   (c) Why did the normal force not enter into your solution?

10. A 2.50-kg mass is pushed against a horizontal spring of force constant 25.0 N/cm on a frictionless table. The spring is attached to the table top and the mass is not attached to the spring in any way. When the spring has been compressed enough to store 11.5 J of potential energy in it, the mass is suddenly released from rest.

    (a) Find the greatest speed the mass reaches and qualitatively when does the greatest speed occur?
    (b) What is the greatest acceleration of the mass and qualitatively when does it occur?

Answers

1. a) 3.60 b) -0.900 J c) 0.0 J, d) 0.0 J e) 2.70 J
2. a) -1750 J b) The gravity force is independent of the motion of the painter.
3. 135 J
4. $\sqrt{2gh(1 + \mu_k/\tan\alpha)}$
5. 246 J
6. 8.17 m/s
7. 28
8. a) N/m^2 b) –0.10 J c) +0.10 J d) Yes, $U(x) = 1/3\ \alpha x^3$
9. $\sqrt{2gd\sin\alpha}$, the normal is perpendicular to displacement and does no work.
10. a) 3.03 m/s, greatest speed occurs when leaves the spring and then slides along the surface with constant speed b) 95.9 m/s^2, greatest acceleration occurs when spring has its maximum compression.