Energy – Challenging Problems and Hooke's Law

Energy Example Problem: Projectiles => A projectile is launched at a 30^o above the horizontal at a speed of 25 m/s. (a) How high does the projectile go from its initial launch point? (b) What is the speed of the projectile if it was launched from a height of 30 m?

Energy Example Problem: Work => A 12 kg box is pushed across the floor with a force of 6 N at an angle of 30^o below the horizontal. (a) How much work is done by the pushing for if the box moves 8 m? (b) If the frictional force is 3 N, how much energy was dissipated over the 8 m? (c) If the box started from rest, how fast is it moving at 8m?

Energy Example Problem: Pendulum => A 2 kg metal ball is attached to a 0.8 m long string. If the ball is pulled back so that the string makes a 12^o angle to the vertical, how fast will it be moving when it reaches the lowest point?

Energy Example Problem: Hooke's Law => An un-stretched spring has a length of 2 cm. (a) If that spring is stretched to the right so that it has a length of 5 cm, what is the force the spring is applying to try and return back to its original un-stretched length? (b) What force must be applied to keep that spring stretched to 5 cm? (c) How much work was done to stretch it to 5 cm?

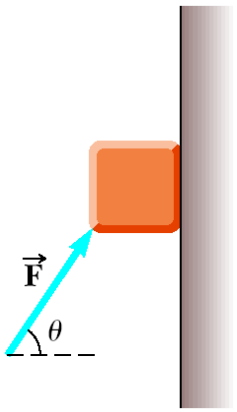
A Focus on Work

1. A shopper in a supermarket pushes a cart with a force of 35 N directed at an angle of 25° downward from the horizontal. The force is just sufficient to overcome various frictional forces, so the cart moves at a constant speed. (a) Find the work done by the shopper as she moves down a 50.0 m length aisle. (b) What is the net work done on the cart? Why? (c) The shopper goes down the next aisle, pushing horizontally ONLY and maintaining the same speed as before. If the work done by frictional forces doesn't change, would the shopper's applied force be larger, smaller, or the same? What about the work done on the cart by the shopper?

2. Starting from rest, a 5.00-kg block slides 2.50 m down a rough 30.0° incline. The coefficient of kinetic friction between the block and the incline is $\mu_k = 0.436$. Determine (a) the work done by the force of gravity, (b) the work done by the friction force between block and incline, and (c) the work done by the normal force. (d) Qualitatively, how would the answers change if a shorter ramp at a steeper angle were used to span the same vertical height?

3. A block of mass 2.50 kg is pushed 2.20 m along a frictionless horizontal table by a constant 16.0-N force directed 25.0° below the horizontal. Determine the work done by (a) the applied force, (b) the normal force exerted by the table, (c) the force of gravity, and (d) the net force on the block.

4. A 5.0-kg block is pushed 3.0 m up a vertical wall with constant speed by a constant force of magnitude F applied at an angle of $\theta = 30°$ with the horizontal, as shown in figure to the right. If the coefficient of kinetic friction between block and wall is 0.30, determine the work done by (a) $\vec{\mathbf{F}}$, (b) the force of gravity, and (c) the normal force between block and wall. (d) By how much does the gravitational potential energy increase during the block's motion?

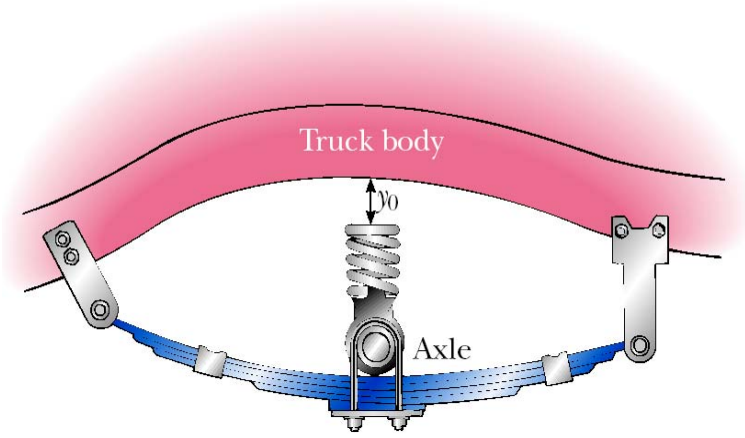


A Focus on Hooke's Law

5. When a 2.50 kg object is hung vertically on a certain light spring described by Hooke's law, the spring stretches 2.76 cm. (a) What is the force constant of the spring? (b) If the 2.5 kg object is removed, how far will the spring stretch if a 1.25 kg block is hung on it and it sits in static equilibrium? (c) How much work must an external agent do to stretch the same spring 8.0 cm from its un-stretched position?

6. An archer pulls her bowstring back 0.400 m by exerting a force that increases uniformly from zero to 230 N. (a) What is the equivalent spring constant of the bow? (b) How much work does the archer do in pulling the bow?

7. Truck suspensions often have "helper springs" that engage at high loads. One such arrangement is a leaf spring with a helper coil spring mounted on the axle, as shown in Figure to the right. When the main leaf spring is compressed by distance y_0, the helper spring engages and then helps to support any additional load. Suppose the leaf spring constant is 5.25×10^5 N/m, the helper spring constant is 3.60×10^5 N/m, and $y_0 = 0.500$ m. (a) What is the compression of the leaf spring for a load of 5.00×10^5 N? (b) How much work is done in compressing the springs?



8. A toy gun uses a spring to project a 5.3-g soft rubber sphere horizontally. The spring is compressed 5.0 cm and applies a force of 0.4 N to the dart. The barrel of the gun is 15 cm long, and a constant frictional force of 0.032 N exists between barrel and projectile. With what speed does the projectile leave the barrel?

9. A 200g marble starts from rest at the top of a 0.5 m high incline. At the bottom of the incline the marble rolls horizontally in the + x direction and runs into a spring which compresses it 2.2 cm at the instant the marble momentarily stops. (a) At that instant, what force is the spring applying to the marble? (b) What would be the acceleration of the marble at that instant? (c) As the spring causes the marble to accelerate away from it, what would the acceleration be when the spring is only compressed 1.0 cm?

A Look Back at Projectiles

10. A projectile is launched with a speed of 40 m/s at an angle of 60° above the horizontal. Use conservation of energy to find the maximum height reached by the projectile during its flight.

11. A 50.0 kg projectile is fired at an angle of 30.0° above the horizontal with a n initial speed of 120 m/s from the top of a cliff 142 m above level ground, where the ground is taken to be y = 0. (a) What is the initial total mechanical energy of the projectile? (b) Suppose the projectile is traveling 85.0 m/s at its maximum height of y = 427 m. How much work has been done on the projectile by air friction? (c) What is the speed of the projectile immediately before it hits the ground if air friction does one and a half times as much work on the projectile when it is going down as it did when it was going up?

12. A ski jumper starts from rest 50.0 m above the ground on a frictionless track and flies off the track at an angle of 45.0° above the horizontal and at a height of 10.0 m above the level ground. Neglect air resistance. (a) What is her speed when she leaves the track? (b) What is the maximum altitude she attains after leaving the track? (c) Where does she land relative to the end of the track?

A Focus on Pendulums

13. Tarzan swings on a 30.0-m-long vine initially inclined at an angle of 37.0° with the vertical. What is his speed at the bottom of the swing (a) if he starts from rest? (b) if he pushes off with a speed of 4.00 m/s?

14. A pendulum is moving at 1.5 m/s at its lowest point. What angle will the string make to the vertical if the string is 2.5 m long and at its highest point?

15. A 1940 kg wrecking ball is attached to a 40 m long wire with a 60 kg Miley sitting on top of it. (a) If the wire is making a 20° to the vertical when released from rest, how much energy was dissipated if it is moving at 5.0 m/s? (b) At the lowest point Miley is slammed into a wall but the speed of the wrecking ball is not effected (What a tragic loss). What angle will the wrecking ball make to the vertical if there isn't any more energy dissipated?