Work and the work-energy theorem

AP Physics 1 - Unit 3 - Problem set

COURSE AP Physics 1 **UNIT** Unit 3: Work, Energy, and Power
TOPIC Work and the work-energy theorem **SET** U3L1

Name _____ Date _____ Period _____

Before you compute anything on a problem, write down the angle between each force and the displacement. That angle decides the sign, and the sign is where these problems are lost. Show every line. Carry units. Where a problem asks you to explain or to show something, write sentences, not a calculation with a label on it.

1. A 15 kg crate is pushed 6.0 m across a level floor by a constant 40 N force directed 25 degrees below the horizontal. (a) Find the work done on the crate by the 40 N force. (b) Find the work done by the normal force and by gravity. (c) Find the magnitude of the normal force.

2. Movers push a 160 kg crate 10.3 m across a rough level floor at constant speed. The effective coefficient of kinetic friction is 0.50. Find (a) the work done by the movers, (b) the work done by friction, and (c) the net work done on the crate. Then state, without computing anything further, how the crate's speed at the end compares with its speed at the start.

3. How much work must be done to stop a 1250 kg car traveling at 105 km/h?

4. A 140 g baseball traveling at 32 m/s is caught. The fielder's glove moves backward 25 cm while the ball comes to rest in it. (a) Find the work done on the ball. (b) Find the average force the ball exerts on the glove. (c) Now do the problem a second time using only $F = ma$ and the kinematic equations, and say what the work-energy theorem saved you.

5. What is the minimum work needed to push a 950 kg car 810 m up a 9.0 degree incline (a) ignoring friction, and (b) if the effective coefficient of friction retarding the car is 0.25?

6. A 2.0 kg block slides 3.0 m down a ramp inclined at 30 degrees. A classmate reports that the work done by gravity is $W = mgd = (2.0)(9.8)(3.0) = 58.8$ J, and draws an arrow labelled W pointing down the ramp on his free-body diagram. He also says the normal force must do some work, since it acts the whole time the block is moving. Which of his three claims are wrong, and what are the correct values?

7. A 2.5 kg block starts from rest on a level floor and is pushed 4.0 m by a constant horizontal 12 N force. Friction on the block is a constant 4.0 N. A classmate computes $W_{net} = (12)(4.0) + (4.0)(4.0) = 64$ J and reports a final speed of 7.2 m/s. Is he right? If not, give the correct speed, and describe one check he could have run on his own answer that would have caught the mistake without redoing the problem.

8. A car of mass m traveling at speed v_0 on a level road locks its brakes and skids to a stop. The coefficient of kinetic friction between tires and road is μ_k. Use no numbers. (a) Show that the skid distance is $d = v_0^2/(2\mu_k g)$. (b) State in one sentence why the mass does not appear in the answer. (c) If the initial speed is increased by 50 percent and nothing else changes, by what factor does the skid distance change?

9. A block of mass m is pulled a distance d across a level floor by a constant force F directed at an angle θ above the horizontal. The coefficient of kinetic friction is μ_k. Using symbols only, write expressions for the work done by (a) F, (b) the normal force, (c) gravity, (d) friction, and (e) the net force. (f) Holding the magnitude of F fixed and increasing θ from zero, does the work done by F increase, decrease, or stay the same? (g) Does the net work behave the same way? Explain.

10. A softball of mass 0.25 kg is pitched at 95 km/h. By the time it reaches the plate 15 m away it has slowed by 10 percent. Neglecting gravity, estimate the average force of air resistance on the ball during the pitch.

11. A 285 kg load is lifted 22.0 m vertically by a single cable, starting from rest, with a constant upward acceleration of $0.160 g$. Find (a) the tension in the cable, (b) the net work done on the load, (c) the work done by the cable, (d) the work done by gravity, and (e) the final speed of the load. (f) A classmate says the work done by the cable should equal the change in kinetic energy. Explain in one sentence why it does not.

12. Free response. A 6.0 kg crate is released from rest at the top of a ramp inclined at 30 degrees above the horizontal and slides 4.0 m down the ramp. The coefficient of kinetic friction between crate and ramp is 0.25. (a) Draw a free-body diagram for the crate. For each force on it, state whether the work it does is positive, negative or zero, and justify each answer by reference to the angle between that force and the displacement. (b) Calculate the work done by gravity. (c) Calculate the work done by the normal force. (d) Calculate the work done by friction. (e) Calculate the speed of the crate at the bottom of the 4.0 m. (f) Without using numbers, show that the speed at the bottom does not depend on the mass of the crate, and state the one feature of this situation that makes that true.