Physics Work

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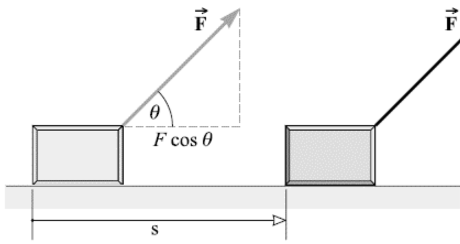
Name: (First)____________(Last)____________

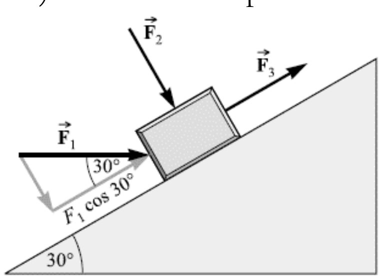
School: _________________ Grade:______

Work and Energy

1. In the figure below, assume that the object is being pulled along the ground by a 75-N force directed 28° above the horizontal. How much work does the force do in pulling the object 8.0 m?



2. A block moves up a 30° incline under the action of certain forces, three of which are shown in the figure below. F_1 is horizontal and of magnitude **40 N.** $\mathbf{F_2}$ is normal to the plane and of magnitude 20 N. $\mathbf{F_3}$ is parallel to the plane and of magnitude 30 N. Determine the combined work done by the forces as the block (and point of application of each force) moves 80 cm up the incline.



3. A 300-g object slides 80 cm along a horizontal tabletop. How much work is done in overcoming friction between the object and the table if the coefficient of kinetic friction is 0.20?

4. How much work is done against gravity in lifting a 3.0-kg object through a vertical distance of 40 cm?

5. How much work is done on an object with mass m by the force that supports it as the object is lowered through a vertical distance h? How much work does the gravitational force on it do in this same process?

6. A ladder 3.0 m long and weighing 200 N has its center of gravity 120 cm from the bottom. At its top end is a 50-N too box. Compute the work required to raise the ladder from a horizontal position on the ground to a vertical position.

7. Compute the work done against gravity by a pump that discharges 600 liters of fuel oil into a tank 20 m above the pump's intake. One cubic centimeter of fuel oil has a mass of 0.82 g. One liter is 1000 cm^3.

8. A 2.0-kg mass falls 400 cm.

(a) How much work was done on it by the gravitational force?

(b) How much PE_G did it lose?

9. A force of 1.50 N acts on a 0.20-kg cart so as to accelerate it along an air track. The track and force are horizontal and in line. How fast is the cart going after acceleration from rest through 30 cm, if friction is negligible?

10. A 0.50-kg block slides across a tabletop with an initial velocity of 20 cm/s and comes to rest in a distance of 70 cm. Find the average friction force that retarded its motion.

11. A car going 15 m/s is brought to rest in a distance of 2.0 m as it strikes a pile of dirt. How large an average force is exerted by seatbelts on a 90-kg passenger as the car is stopped?

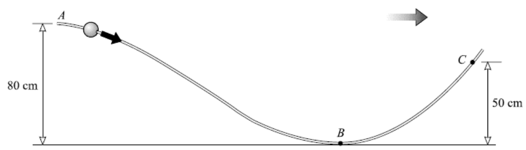
12. A projectile is shot upward from the earth with a speed of 20 m/s. How high is it when its speed is 8.0 m/s? (Ignore air friction.)

13. In an Atwood machine (as below) the two masses are 800 g and 700 g. The system is released from rest. How fast is the 800-g mass moving after it has fallen 120 cm?

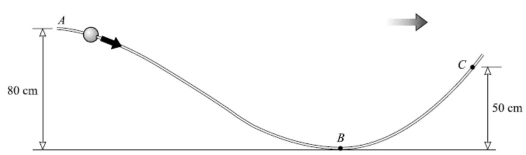
14. The figure below shows a bead sliding on a wire. If friction forces are negligible and the bead has a speed of 200 cm/s at A, what will be its speed

(a) at point B?

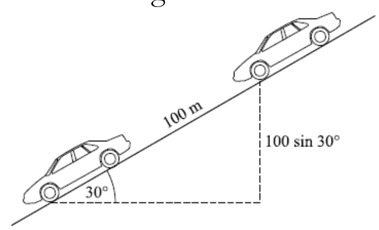
(b) At point C?



15. Suppose the bead in has a mass of 15 g and a speed of 2.0 m/s at A, and it stops as it reaches point C. The length of the wire from A to C is 250 cm. How large an average friction force opposed the motion of the bead?



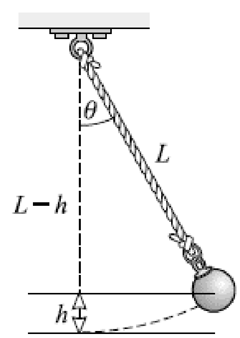
16. A 1200-kg car is coasting down a 30° hill as shown below. At a time when the car's speed is 12 m/s, the driver applies the brakes. What constant force F (parallel to the road) must result if the car is to stop after traveling 100 m?



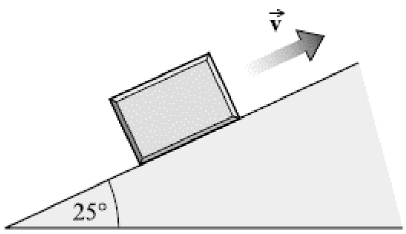
17. A ball at the end of a 180-cm long string swings as a pendulum as shown below. The ball's speed is 400 cm/s as it passes through its lowest position.

(a) To what height h above this position will it rise before stopping?

(b) What angle does the pendulum then make to the vertical?



18. 500-g block is shot up the incline as below with an initial speed of 200 cm/s. How far up the incline will it go if the coefficient of friction between it and the incline is 0.15?



19. A 60,000-kg train is being pulled up a 1.0 percent grade (it rises 1. 0 m for each horizontal 100 m) by a drawbar pull of 3.0 kN. The friction force opposing the motion of the train is 4.0 kN. The train's initial speed is 12 m/s. Through what horizontal distances will the train move before its speed is reduced to 9.0 m/s?

20. An advertisement claims that a certain 1200-kg car can accelerate from rest to a speed of 25 m/s in a time of 8.0 s. What average power must the motor produce to cause this acceleration? Ignore friction losses.

21. An advertisement claims that a certain 1200-kg car can accelerate from rest to a speed of 25 m/s on <u>an incline of 20°</u> in a time of 8.0 s. What average power must the motor produce to cause this acceleration? Ignore friction losses.

22. A 0.25-hp motor is used to lift a load at the rate of 5.0 cm/s. How great a load (mass in kg) can it lift at this constant speed?

23. In unloading grain from the hold of a ship, an elevator lifts the grain through a conveyor belt of 12 m high. Grain is discharged at the top of the elevator at a rate of 2.0 kg/s, and the discharge speed of each grain particle is 3.0 m/s. Find the minimum-horsepower motor that can discharge grain in this way.

24. A force of 3.0 N acts through a distance of 12 m in the direction of the force. Find the work done.

25. A 4.0-kg object is lifted 1.5 m.

(a) How much work is done against the Earth's gravity?

(b) Repeat if the object is lowered instead of lifted.

26. A uniform rectangular marble slab is 3.4 m long and 2.0 m wide. It has a mass of 180 kg. If it is originally lying on the flat ground, how much work is needed to stand it on end?

27. How large a force is required to accelerate a 1300-kg car from rest to a speed of 20 m/s in a distance of 80 m?

28. A 1200-kg car going 30 m/s applies its brakes and skids to rest. If the friction force between the sliding tires and the pavement is 6000 N, how far does the car skid before coming to rest?

29. A proton ($m = 1.67\times10^{-27}$ kg) that has a speed of 5.0×10^{6} m/s passes through a metal film of thickness 0.010 mm and emerges with a speed of 2.0×10^{6} m/s. How large an average force opposed its motion through the film?

30. A 200-kg cart is pushed slowly up an incline. How much work does the pushing force do in moving the cart up to a platform 1.5 m above the starting point if friction is negligible?

Answer Key

1. $W = F\cos(\theta)\cdot s = 75\cos 28°(8)$ = 530 J = 0.53 kJ

```
75cos(28)8
    529.7685557
```

2. Combined (effective) force = $F_1 \cos 30° + F_3$
Combined work =
$(F_1 \cos 30° + F_3)(0.8)$ = (40cos(30°) + 30)(0.8) = 52 J

```
(40cos(30)+30).8
    51.71281292
```

3. 300 g = 0.3 kg
F_μ = 0.3(9.8)·0.2
80 cm = 0.8 m
$W = F_\mu \cdot (0.8)$ = 0.47 J

```
.3(9.8)*.2(.8)
          .4704
```

4. 40 cm = 0.4 m
$W = W \cdot s = (3)(9.8)(0.4)$ = 11.76 J

```
3*9.8*.4
          11.76
```

5. $W_f = -m \cdot g \cdot h$
$W_g = m \cdot g \cdot h$

6. 120 cm = 1.2 m
$W = W_L + W_T = 200(1.2) + 50(3)$ = 390 J = 0.39 kJ

7. M = 600 lit (0.82) = 600(0.82) kg
$W = W \cdot h = Mgh = 600(0.82)(9.8)(20)$ = 96 kJ

```
600*.82*9.8*20
          96432
```

8. a) 400 cm = 4 m
$W = mgh = 2 \times 9.8 \times 4$ = 78 J
b) -78J

```
2*9.8*4
          78.4
```

9. 30 cm = 0.3 m

Method I)
$a = \frac{F}{M} = \frac{1.5}{0.2} = 7.5$
$v^2 = 2a(s) = 2(7.5)(0.3) = 4.5$
v = 2.12 m/s

Method II)
$W = F \cdot s = \frac{1}{2}mv^2$
$(1.5)(0.3) = \frac{1}{2}(0.2)v^2$
$v^2 = \frac{0.45}{0.1} = 4.5$
v = 2.12 m/s

10. 20 cm/s = 0.2 m/s
70 cm = 0.7 m

Method I)
$a = \frac{v^2}{2s}$
$F = ma = m(\frac{v^2}{2s})$ = 0.014 N

```
.5(.2²)/(2*.7)
    .0142857143
```

Method II)
$W = F \cdot s = \frac{1}{2}mv^2$
$F = \frac{\frac{1}{2}mv^2}{s} = \frac{\frac{1}{2}(0.5)(.2^2)}{0.7}$

```
.5*.5*.2²/.7
    .0142857143
```

11. Method I)
$a = \frac{v^2}{2s}$
$F = ma = m \cdot \frac{v^2}{2s} = (90)\frac{15^2}{2(2)}$ = 5.1 kN

```
90*15²/(2*2)
         5062.5
```

Method II)
$W = F \cdot s = \frac{1}{2}mv^2$
$F = \frac{\frac{1}{2}mv^2}{s}$ = 5.1 kN

12. Method I)
$2gh = v_0^2 - v_1^2$
$h = \frac{v_0^2 - v_1^2}{2g}$ = 17.14 (m)

Method II)

$W = mgh = \frac{1}{2}mv_0^2 - \frac{1}{2}mv_1^2$

$h = \frac{\frac{1}{2}m({v_0}^2 - {v_1}^2)}{mg} = \frac{v^2}{2g} = \frac{20^2 - 8^2}{2(9.8)} = 17.14$ (m)

```
(20²-8²)/(2*9.8)
      17.14285714
```

13. 120 cm = 1.2 m
800 g = 0.8 kg
700 g = 0.7 kg
Method I)

$F = Ma$

$a = \frac{w_1 - w_2}{m_1 + m_2} = \frac{m_1 - m_2}{m_1 + m_2}g$

$v^2 = 2as$

$v = \sqrt{2as} = \sqrt{2\left(\frac{0.8-0.7}{0.8+0.7}\right)(9.8)(1.2)} = 1.25$ m/s

```
√2(.1/1.5)(9.8)▸
      1.252198067
```

Method II)

$W = PE_{G_1} - PE_{G_2} = m_1gh - m_2gh = (m_1 - m_2)gh$

$KE_1 + KE_2 = \frac{1}{2}m_1v^2 + \frac{1}{2}m_2v^2 = \frac{1}{2}(m_1 + m_2)v^2$

$(m_1 - m_2)gh = \frac{1}{2}(m_1 + m_2)v^2$

$v = \sqrt{2gh\frac{m_1 - m_2}{m_1 + m_2}} = 1.25$ m/s

14. 200 cm/s = 2 m/s
80 cm = 0.8 m
50 cm = 0.5 m

a) $v = \sqrt{v_0^2 + 2gh} = \sqrt{2^2 + 2(9.8)(0.8)} = 4.4$ m/s

```
√2²+2(9.8)(.8)
      4.436214603
```

b) $v = \sqrt{v_0^2 + 2gh} = \sqrt{2^2 + 2(9.8)(0.3)} = 3.1$ m/s

```
√2²+2(9.8)(.3)
      3.143246729
```

15. 15 g = 0.015 kg
250 cm = 2.5 m
80 – 50 = 30 cm = 0.3 m

$\frac{1}{2}mv^2 + mgh = F_f \cdot s$

$\frac{1}{2}(0.015)(2^2) + (0.015)(9.8)(0.3) = F_f(2.5)$

$F_f = \frac{\frac{1}{2}(0.015)(2^2) + (0.015)(9.8)(0.3)}{2.5} = 0.03$ N

```
1/2.5*(.5*.015*▸
           .02964
```

16. Method I)

$a = \frac{v^2}{2s} + g\sin 30°$

$F = ma = m\left(\frac{v^2}{2s} + g\sin 30°\right) = 1200\left(\frac{12^2}{200} + 9.8(.5)\right) = 6.7$ kN

```
1200(12²/200+9.8▸
             6744
```

Method II)

$W = \frac{1}{2}mv^2 + mgh = F \cdot s$

$F = \frac{\frac{1}{2}mv^2 + mgh}{s} = \frac{\frac{1}{2}v^2 + gh}{s}m = 6.7$ kN

17. 180 cm = 1.8 m
400 cm/s = 4 m/s

a) $\frac{1}{2}mv^2 = mgh$

$h = \frac{v^2}{2g} = \frac{4^2}{2(9.8)} = 0.816$ m

b) $\cos^{-1}\frac{1.8 - 0.81}{1.8} = 56.9°$

```
4²/(2*9.8)
     .8163265306
```

```
cos⁻¹((1.8-.816)▸
      56.86136846
```

18. 500 g = 0.5 kg
200 cm/s = 2 m/s

Method I)

$a = g\sin 25° + g\cos 25°(0.15)$

$v^2 = 2as$

$s = \frac{v^2}{2a} = \frac{2^2}{2(9.8)(\sin 25 + 0.15\cdot\cos 25)} = 3.65$ m

Method II)

$F = F_f + F_g = (mg\cos 25)\cdot 0.15 + mg\sin 25$

$W = F \cdot s = \frac{1}{2}mv^2$

$s = \frac{\frac{1}{2}mv^2}{F_f + F_g} = \frac{\frac{1}{2}mv^2}{(mg\cos 25)\cdot 0.15 + mg\sin 25} = \frac{v^2}{2[(g\cos 25)\cdot 0.15 + g\sin 25]} = 3.65$ m

19. $a = g\frac{1}{100} + \frac{4{,}000 - 3{,}000}{60{,}000} = 0.098 + 0.017 = 0.115$

$v_1^2 = v_0^2 + 2as$

$s = \frac{v_1^2 - v_0^2}{2a} = \frac{12^2 - 9^2}{2(a)}$ = 273 m = 0.273 km

```
(12²-9²)/(2*.115▸
      273.9130435
```

20. $\frac{KE}{t} = \frac{\frac{1}{2}mv^2}{t} = \frac{\frac{1}{2}\times 1200 \times 25^2}{8}$ = 47 kJ/s = 47 kW

21. Distance = $\frac{1}{2}vt = \frac{1}{2}(25)(8)$ = 100

    $\frac{KE+PE_G}{t} = \frac{\frac{1}{2}mv^2 + mgh}{t} =$

    $\frac{.5(1200)25^2 + 1200(9.8)(100\sin 20)}{8}$ = 97 kJ/s

```
(.5*1200*25²+120▸
     97151.96107
```

22. 5 cm/s = 0.05 m/s

    0.25 hp = 0.25×746 watt = $mg\frac{h}{t}$ = m (9.8)(0.05)

    $m = \frac{0.25\times 746}{9.8\times 0.05}$ = 380 kg

```
746*5/9.8
     380.6122449
```

23. Power = $\frac{PE_G + KE}{time\ taken} = \frac{mgh + \frac{1}{2}mv^2}{t} = \frac{m}{t}\left(gh + \frac{1}{2}v^2\right) = 2\left(9.8\times 12 + \frac{1}{2}3^2\right)$ = 244 W = 0.244 kW

24. $W = F \cdot s$ = 3×12 = 36 J

25. a) $W = W \cdot s$ = 4×9.8×1.5 = 58.8 J

    b) -58.8 J

26. $W = F \cdot s$ = 180×9.8×1.7 = 3 kJ

27. $W = F \cdot s = \frac{1}{2}mv^2$

    $F = \frac{\frac{1}{2}mv^2}{s} = \frac{\frac{1}{2}(1300)20^2}{80}$ = 3.25 kN

```
.5*1300*20²/80
           3250
```

28. $W = F \cdot s = \frac{1}{2}mv^2$

    $s = \frac{\frac{1}{2}(1200)30^2}{6000}$ = 90 m

```
.5*1200*30²/6000
               90
```

29. $W = F \cdot s = \frac{1}{2}mv^2$

    $F = \frac{\frac{1}{2}(1.67\times 10^{-27})(5\times 10^6)^2}{\frac{0.01}{1000}}$ = 2×10^{-9} N

```
.5*1.67*5²
      20.875
-27+12-(-5)
         -10
```

30. $W = F \cdot s$ = 200(9.8)(1.5) = 2.94 kJ

```
200*9.8*1.5
        2940
```