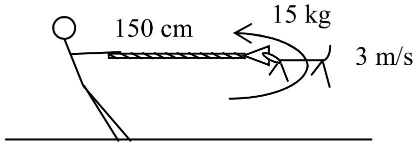
Due Wed., Nov. 30

2011 PreAP Energy 11



1. A tetherball is held by a rope and goes around in a circular path. Assume the rope is parallel to the ground.
   A. * Calculate the centripetal acceleration of Bim (the dog).
   B. What force provides this acceleration?
   C. * Calculate the centripetal force.
   D. What is the angle between the force and Bim's velocity?
   E. * Calculate the work the rope does in one half of a circle.

2. A 30 N object is lifted 5 m in 2 seconds.
   A. * How much potential energy was gained?
   B. How much work was done to lift the object?
   C. How much power was used to lift the object?

3. A spring has a spring constant of 50 N/m. How much work must be done to stretch the spring 0.25 m?

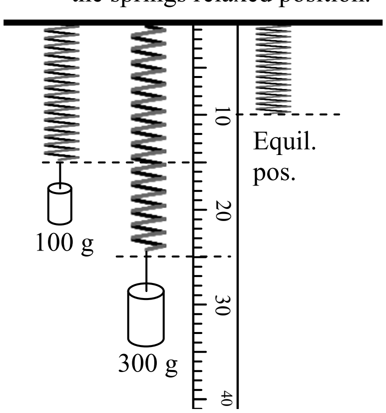
4. A 45 N object is accelerated from rest to 12 m/s. How much work was done on the object?

5. * How much energy does a 60 W light bulb use in 3 minutes?

6. To overcome friction, a force of 16 N must be applied to keep an object moving at a constant speed of 3 m/s. How much power was generated by the force?

7. * A 120 W motor pulls on a rope. The rope is connected to a 2 kg object. How fast is the mass going after 10 seconds?

8. In the equation $\frac{1}{2}kx^2$, x is the distance stretched or compressed from the equilibrium position. The equilibrium position is the springs relaxed position. Assume the picture shows different masses on the same spring.



   A. * What is the equilibrium position for this spring?
   B. * What is x for the 100g mass?
   C. * Calculate the spring constant for the spring in N/m.
   D. * Calculate the potential elastic energy of the 100g mass.
   E. What is x for the 300g mass?
   F. * Calculate the elastic energy of the 300g mass.
   G. * x_{300g} is ____ times as great as x_{100g}.
   H. Divide part F by part C.

Notice that x was tripled and PEel increased by a factor of 9. You could see this in the equation. Since x is squared ($\frac{1}{2}kx^2$), 3 times the distance is 9 times the elastic energy.

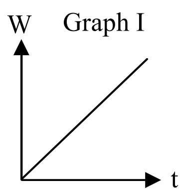
cs

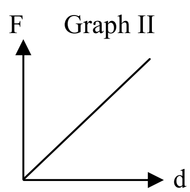
More on back.

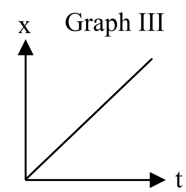
Continuing to read the equations in this way...

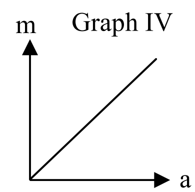
9. If I double the spring constant, the potential elastic energy:
10. * If I double the mass, the potential elastic energy:
11. If I double the mass, the kinetic energy:
12. If I double the height, the gravitational potential energy:
13. * If I double the velocity, the kinetic energy:
14. If I half the velocity, the kinetic energy:

Physics basics, again.
Division = slope. When you see m/s (speed), that's the slope of a position vs time graph. Anything in an equation that is divided is slope of a graph. Examples: $a = \Delta v/t$ or $P = W/t$. All of these are slope.
Multiplication = area. Whenever an equation has multiplied variables, graphically, you find the area on the graph. Examples: $W = Fd$, $D = ST$. Often it is easier to use the units. For example: Work is in joules or N•m. Multiple force in N by distance (or displacement) in m.









15. Decide which graph and which process (slope or area) you would use to find the following.
    A. * To calculate power:
    B. * To calculate torque:
    C. To calculate spring constant:
    D. To calculate speed:
    E. To calculate force:
    F. To calculate work:

1A) 6 m/s^2 1C) 90 N 1E) none. $W = Fd\cos\theta$, $\theta = 90°$ and $\cos 90° = 0$.
2A) 150 J 5) 10,800 J 7) 34.6 m/s 8A) 10 cm (0.1 m) 8C) 20 N/m (1N/0.5m)
8D) 0.025 J 8F) 0.225 J 8G) 3 times as far
10) no change, since no mass in eq. 13) 4 times as much, since v is squared
15A) slope of Graph I (W/t) 15B) area of Graph II (Fd)

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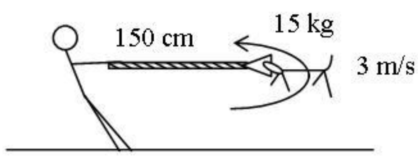


1. A tetherball is held by a rope and goes around in a circular path. Assume the rope is parallel to the ground.
   - A. * Calculate the centripetal acceleration of Bim (the dog).
     $v^2/r = 9/1.5 = \frac{90}{15} = \frac{30}{5} = 6\ m/s^2$
   - B. What force provides this acceleration? tension
   - C. * Calculate the centripetal force. $F = ma = 15(6) = 90N$
   - D. What is the angle between the force and Bim's velocity? $90°$
   - E. * Calculate the work the rope does in one half of a circle.
     None. $W = F_{\parallel} d$ or $Fd\cos\theta$, $\cos 90° = 0$

2. A 30 N object is lifted 5 m in 2 seconds.
   - A. * How much potential energy was gained? mgh and mg = 30N, so 30(5) = 150 J
   - B. How much work was done to lift the object?
     150 J $\quad 0 + W = PE$ so $W = PE$
   - C. How much power was used to lift the object?
     $P = \frac{W}{t}$ or $\left[\frac{J}{s}\right] = \frac{150\ J}{2\ sec} = 75$ watts

3. A spring has a spring constant of 50 N/m. How much work must be done to stretch the spring 0.25 m?
   $0 + W = PE_{el}$
   $W = \frac{1}{2}kx^2 = \frac{1}{2}(50)(\frac{1}{4})^2 = \frac{25}{16} = 1.56\ J$

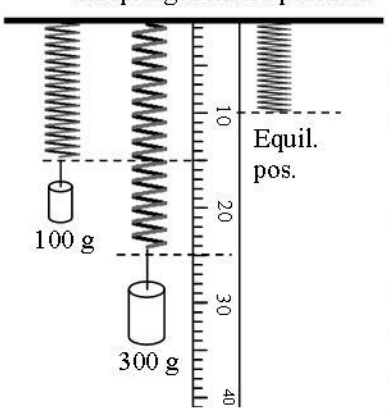
4. A 45 N object is accelerated from rest to 12 m/s. How much work was done on the object?
   $0 + W = KE$ $\quad W = \frac{1}{2}(4.5)(12^2) = 324\ J$
   $W = \frac{1}{2}mv^2$
   $mg = 45N$ so $m = 4.5\ kg$

5. * How much energy does a 60 W light bulb use in 3 minutes?
   $P = \frac{W}{t} = \frac{J}{s}$ $\quad J = $ watts(sec) $= 60\frac{J}{s}\ 3(60)$ sec $= 10{,}800$ joules

6. To overcome friction, a force of 16 N must be applied to keep an object moving at a constant speed of 3 m/s. How much power was generated by the force?
   $P = \frac{W}{t} = \frac{Fd}{t} = Fv = 16(3) = 48$ watts

7. * A 120 W motor pulls on a rope. The rope is connected to a 2 kg object. How fast is the mass going after 10 seconds?
   $120\frac{J}{s}(10\ sec) = 1200\ J = \frac{1}{2}mv^2$ $\quad v = \sqrt{1200} = 34.6\ m/s$
   $1200 = \frac{1}{2}(2)v^2$

8. In the equation $\frac{1}{2}kx^2$, x is the distance stretched or compressed from the equilibrium position. The equilibrium position is the springs relaxed position.



   - A. * What is the equilibrium position for this spring? 10 cm (.1 m)
   - B. * What is x for the 100g mass? 5 cm or .05 m
   - C. * Calculate the spring constant for the spring in N/m.
     100g = .1 kg $\quad k = \frac{1N}{.05m} = \frac{100}{5} = 20\ N/m$
     mg = 1 N
   - D. * Calculate the potential elastic energy of the 100g mass.
     $\frac{1}{2}kx^2 = \frac{1}{2}(20)(.05)^2 = .025\ J$
   - E. What is x for the 300g mass? 15 cm or .15 m
   - F. * Calculate the elastic energy of the 300g mass. $\frac{1}{2}(20)(.15)^2 = .225\ J$
   - G. * x_{300g} is 3 times as great as x_{100g}.
   - H. Divide part F by part C. $\frac{.225}{.025} = 9$

Notice that x was tripled and PEel increased by a factor of 9. You could see this in the equation. Since x is squared ($\frac{1}{2}kx^2$), 3 times the distance is 9 times the elastic energy.

More on back.

Continuing to read the equations in this way...

9. If I double the spring constant, the potential elastic energy: $\frac{1}{2}kx^2$ so doubled PE_{el}

10. * If I double the mass, the potential elastic energy: no Δ, no mass in eq.

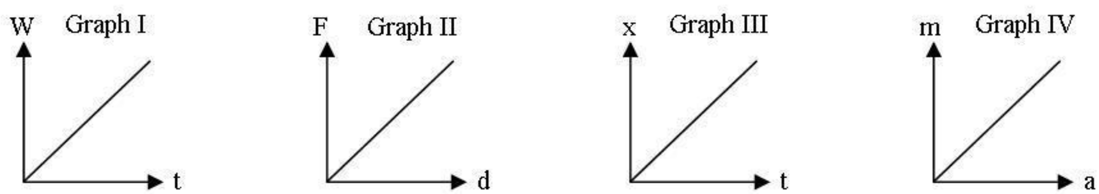
11. If I double the mass, the kinetic energy: $\frac{1}{2}mv^2$ so KE is doubled

12. If I double the height, the gravitational potential energy: mgh, so doubles

13. * If I double the velocity, the kinetic energy: $\frac{1}{2}mv^2$, so 4 times as much

14. If I half the velocity, the kinetic energy: $(\frac{1}{2})^2$ gives $\frac{1}{4}$ as much KE

Physics basics, again.
Division = slope. When you see m/s (speed), that's the slope of a position vs time graph. Anything in an equation that is divided is slope of a graph. Examples: $a = \Delta v/t$ or $P = W/t$. All of these are slope.
Multiplication = area. Whenever an equation has multiplied variables, graphically, you find the area on the graph. Examples: $W = Fd$, $D = ST$. Often it is easier to use the units. For example: Work is in joules or N•m. Multiple force in N by distance (or displacement) in m.



15. Decide which graph and which process (slope or area) you would use to find the following.
    A. * To calculate power: $\frac{W}{t}$, so slope of Graph I
    B. * To calculate torque: $\tau = Fd$, so area of Graph II
    C. To calculate spring constant: $\frac{N}{m}$, so slope of Graph II
    D. To calculate speed: m/s, so slope of Graph III
    E. To calculate force: $F = ma$, so area of Graph IV
    F. To calculate work: $W = Fd$, so area of Graph II