Problems

18. A squirrel (m=1.5 kg) can climb a vertical wall of 10. m in 5.0 s.
    a) How much work does it do?

$$W_{NC} = \Delta E_K + \Delta E_P$$
$$W_{NC} = E_{g2} - E_{g1}$$
$$W_{NC} = mgh$$
$$W_{NC} = (1.6\ kg)(9.8\ m/s^2)(10\ m)$$
$$W = 147\ J$$
$$W = 150\ J$$

    b) How much power does it exert in watts?

$$P = \frac{W}{\Delta t}$$
$$P = \frac{150\ J}{5.0\ s}$$
$$P = 3.0 \times 10^1\ J$$

    c) How much power in horsepower?

$$P = (3.0 \times 10^1\ J)(746\ \ J/hp)$$
$$P = 0.040\ hp$$

19. A truck exerts a force of 2000. N to pull a car (m=1000 kg) at a constant speed of 10. km/h over a level distance of 2.0 km.
    a) How much work does the truck do?

$$W = Fd\cos(\theta)$$
$$W = (2000\ N)(2000\ m)$$
$$W = 4.0 \times 10^6\ J$$

    b) How much work is done on the car?

$$W_{NC} = \Delta E_K + \Delta E_P$$
$$W_{NC} = 0\ J$$

    c) How much power in watts does the truck exert?

$$\Delta\vec{d} = \vec{v}_1\Delta t + \tfrac{1}{2}\vec{a}\Delta t^2$$
$$\Delta d = v\Delta t$$
$$\Delta t = \frac{\Delta d}{v}$$

$$P = \frac{W}{\Delta t}$$
$$P = \frac{vW}{\Delta d}$$
$$P = \frac{(2.778\ m/s)(4.0\times10^6\ J)}{2000\ m}$$
$$P = 5560\ W = 5600\ W$$

20. A racing car (m=800. kg) accelerates from rest so that it covers 0.40 km in 10.0 s. Calculate the power required in watts and horsepower.

$\vec{v}_1$= 0m/s [→]

$\Delta\vec{d}$= 400m [→]

Δt= 10.0s

$\vec{a}$= ?

$\Delta\vec{d} = \vec{v}_1\Delta t + \frac{1}{2}\vec{a}\Delta t^2$

$\vec{a} = \frac{\Delta\vec{d} - \vec{v}_1\Delta t}{\frac{1}{2}\Delta t^2}$

$\vec{a} = \frac{400m - 0m/s(10.0s)}{\frac{1}{2}(10.0s^2)}$

$\vec{a} = 8\ m/s^2\ [fwd]$

$\sum\vec{F} = \vec{F}_{app} = m\vec{a}$

$\vec{F}_{app} = (800\ kg)(8\ m/s^2[fwd])$

$\vec{F}_{app} = 6400\ N\ [fwd]$

$W = \vec{F}d\cos\theta$

$W = (6400\ N)(400\ m)$

$W = 2.56 \times 10^6\ J$

$P = \frac{W}{\Delta t} = \frac{2560000J}{10.0s} = 2.6x10^5 W$

$P = 2.56 \times 10^5\ W$

$\frac{1\ h.p}{746W} = \frac{xh.p}{2.56x10^5W}$

$xh.p = \frac{1\ h.p}{746W}(2.56x10^5W)$

$x = 340\ h.p.$

21. A truck (m= 5000 kg) accelerates from rest to 20 m/s in 20 seconds. Assume the frictional forces are zero and calculate

a) the work done on the truck

$W_{NC} = \Delta E_K + \Delta E_P$

$W_{NC} = (0.5mv^2 - 0\ J) + (0\ J)$

$W_{NC} = (0.5)(5000\ kg)(20\ m/s)^2$

$W_{NC} = 1.0 \times 10^6\ J$

b) the power generated by the truck

$P = \frac{W}{\Delta t}$

$P = \frac{1.0\ x\ 10^6\ J}{20\ s}$

$P = 5.0 \times 10^4\ W$

c) the horsepower generated by the truck

$x\ h.p = \frac{5.0\ x\ 10^4\ W}{746\ W/h.p}$

$x = 67\ h.p.$

22. A golf ball (mass 100. g) travelling horizontally at 90. km/h strikes the side of a hill. If it penetrates a distance of 14 cm before it comes to rest, calculate:

a) the work done on the ball as it slows down.

$$W_{NC} = \Delta E_k + \Delta E_p$$
$$W_{NC} = \left(0\,J - \tfrac{1}{2}mv_1^2\right) + (0\,J - mgh)$$
$$W_{NC} = (0\,J - \tfrac{1}{2}(0.1kg)(25\,m/s)^2) + (0\,J - (0.1kg)(9.8m/s^2)(0.14m)$$
$$W_{NC} = -31 - 0.14$$
$$W_{NC} = -31\,J$$

b) the force exerted on the ball as it slows down.

$$W = Fd\cos(\theta)$$
$$F = -\frac{W}{d}$$
$$F = -\frac{31\,J}{0.14\,m}$$
$$F = -221\,N$$

c) the power dissipated as the ball comes to rest.

$$\Delta d = \frac{1}{2}(v_1 + v_2)\,\Delta t$$
$$\Delta t = \frac{2\Delta d}{(v_1+v_2)}$$
$$\Delta t = \frac{2(0.14\,m)}{(25\,m/s + 0\,m/s)}$$
$$\Delta t = 0.0112\,s$$

$$P = \frac{W}{\Delta t}$$
$$P = \frac{-31\,J}{0.0112\,s}$$
$$P = 2.8x10^3\,W$$

23. A car (m=1200 kg) starts from rest and accelerates up a hill. After a time of 10.0 s, the car is travelling at a speed of 25 m/s. If the effective horsepower of the car is 80 hp, what is the vertical height of the car relative to its starting point? Ignore frictional effects.

$$P = \frac{W}{\Delta t}$$
$$W = P\Delta t$$

$$W_{NC} = \Delta E_k + \Delta E_p$$
$$P\Delta t = \left(\tfrac{1}{2}mv^2 - 0\,J\right) + (mgH - 0\,J)$$
$$H = \frac{P\Delta t - \frac{1}{2}mv^2}{mg}$$
$$H = \frac{(80\,hp)(746\,J/hp)(10.0\,s) - \frac{1}{2}(1200\,kg)(25\,m/s)^2}{(1200\,kg)(9.8m/s^2)}$$
$$H = 18.86\,m$$
$$H = 19\,m$$

24. A slab of rock (m = 2000. kg) starts from rest at the top of a hill and slides toward the bottom. As it slides down, it loses energy at a rate of 5.0 kW due to the friction. After it has slid for time X, it has dropped a vertical height of 10.0 m. At this time it is moving at 5.0 m/s. Calculate X.

$$P = \frac{W}{\Delta t}$$
$$W = P\Delta t$$

$$W_{NC} = \Delta E_k + \Delta E_p$$
$$-PX = \left(\tfrac{1}{2}mv^2 - 0\,J\right) + (0\,J - mgh)$$
$$X = \frac{mgh - \frac{1}{2}mv^2}{P}$$
$$X = \frac{(2000\,kg)(9.8 m/s^2)(10.0\,m) - \frac{1}{2}(2000\,kg)(5.0\,m/s)^2}{5.0\,kW}$$
$$X = 34.2\,s$$
$$X = 34\,s$$

25. A driver notices that her 1150-kg car slows down from 85 km/h to 65 km/h in about 6.0 s on the level when it is in neutral. Approximately what power (watts and hp) is needed to keep the car travelling at a constant 75 km /h?

$$W_{NC} = \Delta E_k + \Delta E_p$$
$$W_{friction} = \left(\tfrac{1}{2}mv_2^2 - \tfrac{1}{2}mv_1^2\right) + (0\,J - 0\,J)$$
$$W = \tfrac{1}{2}(1150\,kg)((18.06\,m/s)^2 - (23.61\,m/s)^2)$$
$$W = -1.330 \times 10^5\,J$$

$$P_{friction} = \frac{W_{friction}}{\Delta t} = \frac{-1.330\times 10^5\,J}{3.0\,s} = -2.216 \times 10^4\,W$$

$$P_{needed\ for\ constant\ 75\ km/h} = -P_{friction}$$
$$P_{needed\ for\ constant\ 75\ km/h} = 2.2 \times 10^4\,W$$
$$P_{needed\ for\ constant\ 75\ km/h} = 3.0 \times 10^1\,hp$$