Power: $P = \vec{F} \cdot \vec{V}$

$P = dW/dt$

Ex: Car mass 1200kg Requires 20hp to drive at 50km/hr on level road

Find Force of Friction

$F_F = \frac{P}{V} = \frac{20\text{hp}(.746\text{kW/hp})}{50\frac{\text{km}}{\text{hr}}\left(\frac{1}{3600}\frac{\text{hr}}{\text{sec}}\right)} = 1070\text{N}$

Car goes up a 10% Grade (10m up in 100m)

$\Rightarrow$ Speed up = 5 km/hr

if speed across remains 50km/hr

$\left(5\frac{\text{km}}{\text{hr}} \times\right)\left(\frac{1}{3600}\frac{\text{hr}}{\text{sec}}\right) = 1.389\,\text{m/s}$

Force of gravity = mg = $9.8\text{m/s}^2 \cdot 1200\text{kg}$ = $1.176\times10^4\text{N}$

$P = F \cdot V = (1.176\times10^4\text{N})\left(1.39\frac{\text{m}}{\text{s}}\right)$

$= 1.63\times10^4\text{W} = 16.3\text{kW}\,\frac{1\text{ hp}}{.746\text{ kW}}$

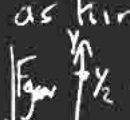
$= 21.9\text{ hp}$ = Power to go up

Total Power = 20hp + 21.9hp

= 41.9hp $\neq$ 42hp

Gravitational Potential Energy

Work done against gravity Stored in GPE, released as kinetic energy



$W_{grav} = F_{grav}(Y_2 - Y_1)$

$= -mg(Y_2 - Y_1)$

Gravitational Potential Energy $= U = mgy \Rightarrow$

$W_{grav} = -\Delta U$

Let W' = Work by all Forces except Gravity

K = Kinetic Energy

$W' + W_{grav} = K_2 - K_1$

$W' - (mgy_2 - mgy_1) = \frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$

$W' = (\frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2) + (mgy_2 - mgy_1)$

$W' = (\frac{1}{2}mv_2^2 + mgy_2) - (\frac{1}{2}mv_1^2 + mgy_1)$

If $W' = 0$ (i.e. only gravity)

$\frac{1}{2}mv_2^2 + mgy_2 = \frac{1}{2}mv_1^2 + mgy_1$

Start from $y_1 = 0$, $v_1 = 0$

$\frac{1}{2}mv^2 + mgy = 0$

$\frac{1}{2}v^2 = -gy$

$v = \sqrt{-2gy} = \sqrt{2as}$

True for non Constant acceleration and forces

Curved Track

At start, use mechanical energy

$K_1 + U_1 = K_2 + U_2$

$0 + mgR = \frac{1}{2}mV_2^2 + 0$

$V_2 = \sqrt{2gR}$

Now add friction to the track

$R = 1m$, $V_2 = 1\frac{m}{s}$

$m = 2kg$

Work done by Friction

$K_1 + U_1 = mgR$

$= K_2 + W_F$

$W_F = mgR - \frac{1}{2}mV_2^2$

$= 2kg \cdot 9.8\frac{m}{s^2} \cdot 1m - \frac{1}{2} 2kg \left(1\frac{m}{s}\right)^2 = 3.6\ J$

Block continues from 2 → 3, stops after 3m

What is coefficient of kinetic Friction?

$W_F = \frac{1}{2}mV_2^2$ ← all of this KE is lost as work against friction

K.E $V_3 = 0$ $W_F = K_2 - K_3 = \frac{1}{2}mV_2^2 - 0$

$W_F = \frac{1}{2}mV_2^2 = \frac{1}{2} 2kg \left(1\frac{m}{s}\right)^2 = 1\ N\cdot m$

$W_F = F_F \cdot d = F_F \cdot 3m \Rightarrow F_F = \frac{1\ Nm}{3m} = 0.33N$

$= \mu_K N = \mu_K mg = \mu_K 2kg\ 9.8\frac{m}{s^2} = \mu_K 19.6N$

$\mu_K = 0.33N / 19.6N = 0.17 = \mu_K$

Sphere of mass m on weightless line
⇒ Pendulum. length = .5m = d
Swings at max angle 60° w.r.t. Vertical
⇒ Velocity thru vertical?

$U_1 + K_1 = mgh + \frac{1}{2}mV^2$ (0 = $\frac{1}{2}mV^2$)

$U = mgh$

$= mgd\sin 30°$

At lowest point $h = 0 \Rightarrow U_2 + K_2 = \frac{1}{2}mV^2$

$U_1 + K_1 = U_2 + K_2 \Rightarrow \frac{1}{2}mV^2 = mgd\sin 30°$

$V^2 = 2gd\sin 30° = 2(9.8 m/s^2)(0.5m)(0.5) = 4.9 m^2/s^2 \Rightarrow V = 2.2 m/s$

Elastic Potential Energy (Spring)

F = elastic force

Work to stretch a spring distance x

$W_{sp} = \frac{1}{2}kx^2$

Spring released $\frac{1}{2}kx^2$ released

Total Energy of a spring / mass system

$E = U + K =$

$\frac{1}{2}kx^2 + \frac{1}{2}mv^2$

$\frac{1}{2}kx^2$ = Elastic PE

mgh = Grav. P.E.

$\frac{1}{2}mv^2$ = K.E.

Gravity, Spring, Kinetic Energy

80 kg person jumps from height of 2 m onto spring which compresses 0.2 m and rebounds. Find speed when compressed 0.1 m

Set Y coord = 0 at lowest point

Find initial GPE

$U = mgh =$

$80\,kg \; 9.8\,\frac{m}{s^2} \; 2.2\,m$

$= 1725\,J$