WORK ENERGY AND POWER PART 2

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IG: elevateig_tutoring
Email: elevateigtutor@gmail.com

Power:

- The rate at which work is done or energy is transferred.
  - → Formula: $P = \frac{W}{t}$
    - measure in Watts
    - Power can also be expressed as $P = F \cdot v$

Examples:

(1) A block of mass m=5kg is released from rest at height h=20m. Calculate speed of the block just before it hits the ground

Givens:
Mass: 5 kg
height: 20 m
$g = 9.81\ m/s^2$

Unknowns:
$V_f = ?$

Solution:

(1) Calculate initial potential energy:

$PE = mgh$
$= 5 \times 20 \times 9.81$
$= 981J$

h=20m

PE=KE

(2) Due to conservation of energy all PE → KE therefore at final point PE=KE

PE = 981 J

KE = $\frac{1}{2}mv^2$

$981 = \frac{1}{2}(5)v^2$

$981 = \frac{5}{2}v^2$ | $v^2 = \frac{981 \times 2}{5}$ | $\sqrt{v^2} = \sqrt{392.4}$

$v = 19.8\ m/s$

(2) A car of mass m=1000 kg accelerates from rest to a speed of v=25m/s. Calculate the work done on the car.

Givens:
m=1000kg
V_i=0 m/s
V_f=25m/s

Unknowns:
W=?

Solution:

(1) Find KE_f and KE_i

$KE_i = \frac{1}{2}mv^2 = 0$

$W = \Delta KE$
$KE_f - KE_i$

$KE_f = \frac{1}{2}mv_f^2$
$= \frac{1}{2}(1000)(25)^2$
$= 500(25)^2$
$= 312500\ J$

(2) $W = \Delta KE$
$= KE_f - KE_i$ ($v_i = 0$)
$= 312500 - 0$
$= 312500J$

(3) A 10kg block slides down a 30° incline that is 5m long. The coefficient of kinetic friction between the block and the incline is 0.2. Calculate the speed of the block at the bottom of the incline

Givens:
m=10kg
d=5m (length of the incline)
θ=30°
$\mu_k = 0.2$
$g = 9.81\ m/s^2$

Unknowns
$V_f = ?$

Solution:

(1) Calculate the height of the incline

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$\sin\theta = \frac{opp}{hyp}$
$opp = hyp \sin\theta$
$h = d \sin\theta$
$h = 5\sin 30$
$= 2.5m$

(2) Calculate the initial potential energy (PE):

$PE = mgh$
$= 10 \times 9.81 \times 2.5$
$= 245.25J$ → V_i

(3) Calculate the force of friction

$W = Fd$
$W = Fd\cos\theta$ → $\cos(0) = 1$, $\cos(270) = 0$

$F_N = mg\cos\theta$
$= 10(9.81)\cos(30)$
$= 84.97N$

$F_k = \mu_k F_N$
$= 0.2 \times 84.97$
$= 16.97N$

(4) Calculate the work done against friction:

$W_f = F_k d \cos(180)$
$= 16.97 \times 5\ (-1)$
$= -84.85J$

$F \cdot d\cos\theta$ → F_k

(5) Calculate net work:

$W_{net} = \Delta KE$
$= \frac{1}{2}mV_f^2 - \frac{1}{2}mV_i^2$ ($KE_i = 0$)
$245.25 - 84.85 = \frac{1}{2}(10)v^2 - 0$
$160.4 = \frac{1}{2}(10)v^2$
$160.4 = 5v^2$
$\sqrt{v^2} = \sqrt{\frac{160.4}{5}}$ | $v = 5.67\ m/s$

$\cos(180) = -1$

$W_{net} = PE + W_f$
V_i V_f

$PE = W_f$

(4) A crane lifts a load of 500kg to a height of 10m in 8 seconds. Calculate the power output of the crane.

Givens:
m=500kg
h=10m
t=8s
$g = 9.81\ m/s^2$

Unknowns:
Power=?

Solution:

(1) Calculate work done against gravity

$W = mgh$
$= 500 \times 9.81 \times 10$
$= 49050J$

$W = F \cdot d\cos\theta$
$= (mg)(h)\cos\theta$ → 0

(2) Calculate Power:

$P = \frac{W}{t} = \frac{49050}{8} = 6131.25W$