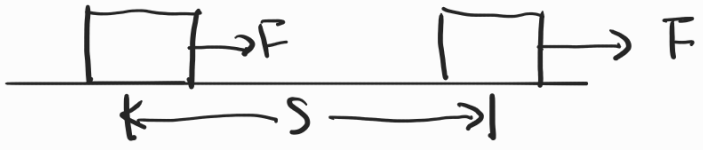
MECHANICAL WORK 機械功

功 Work is the energy transferred by a force acting through a displacement

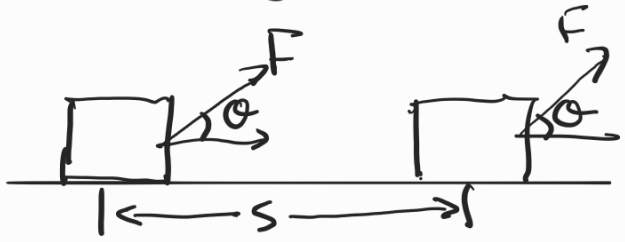
$W = Fs$ SI Unit: J (Joule)

W: Work, F: Force, s: displacement

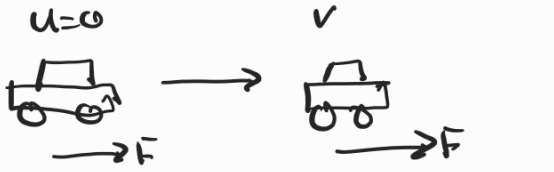
$1\,J = 1\,Nm = 1\,(kg)(ms^{-2})(m)$



$W = Fs$

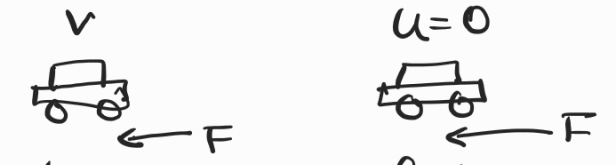


$W = Fs\cos\theta$



initial work = 0 final work = high

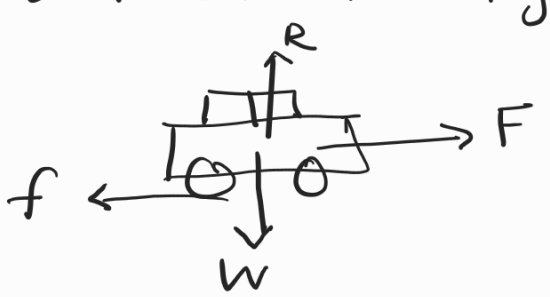
acceleration: Positive Work



initial work = high final work = 0

deceleration: Negative Work

Also: Friction is negative work



F: energy gain
f: energy loss
R: no work
W: no work

MECHANICAL ENERGY 機械能

(KE) Kinetic Energy. Energy possessed by moving mass

動能

$KE\ (J) = \frac{1}{2} m v^2$ (scalar)

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m: mass, v: velocity

Work done enables the change in KE

(PE) Potential Energy (勢能) - energy stored in the object

gravitational PE - energy stored when it is raised higher

gravitational PE (重力勢能) $= mgh$ $(\Delta PE = mg\Delta h)$

m: mass, g: g constant, h: height

Mechanical Energy = KE + PE

and $W = \Delta KE + \Delta PE$

W: Work done by the force over a distance

ΔKE: change in kinetic energy

ΔPE: change in potential energy

Examples

(i) Work done by pushing a block 3m with Force 2N. $W = 3 \times 2 = 6J$

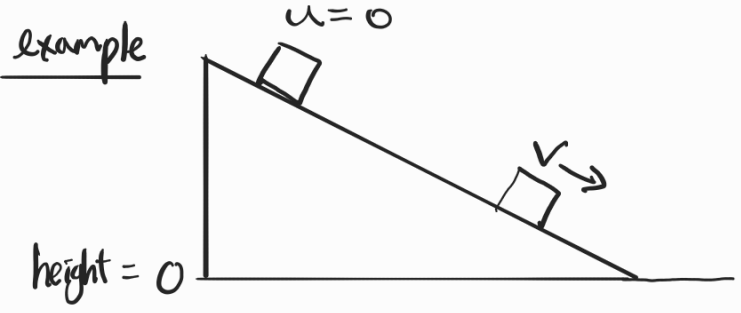
(ii) KE of a bullet (0.005kg) at speed $300 ms^{-1}$: $KE = \frac{1}{2}(0.005)(300)^2 = 255J$

(iii) gravitational PE of a box 5kg, 1.2m above ground: $PE = 5 \times 9.81 \times 1.2 = 58.86J$

Law of Conservation of Energy

Energy cannot be created or destroyed, but it can change from one form to another

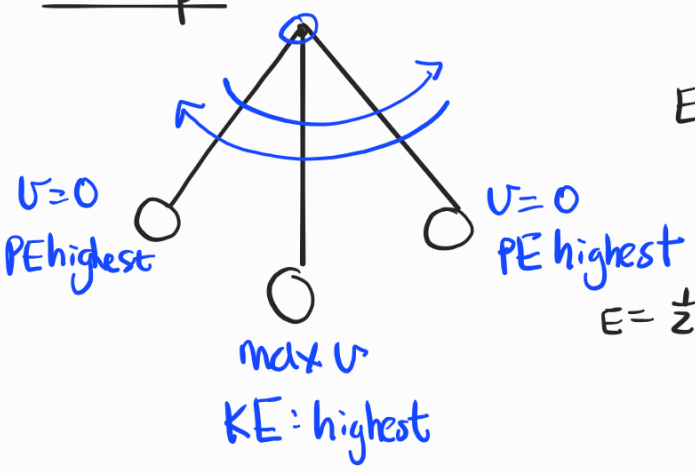
example

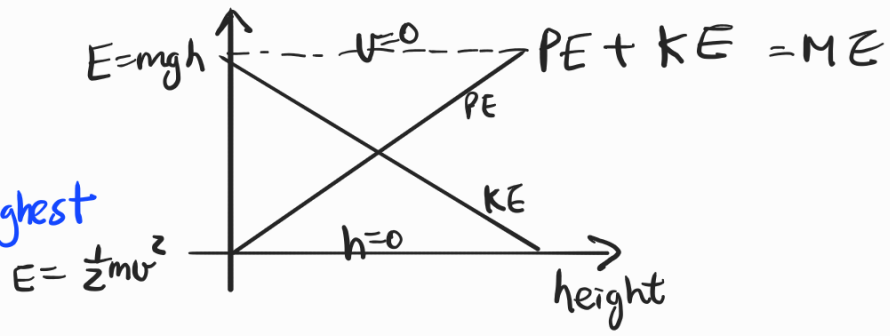


initial state: 6J

final state:
- PE = 2J
- KE = 2J
- Heat loss = 2J

example





POWER

Energy per unit time

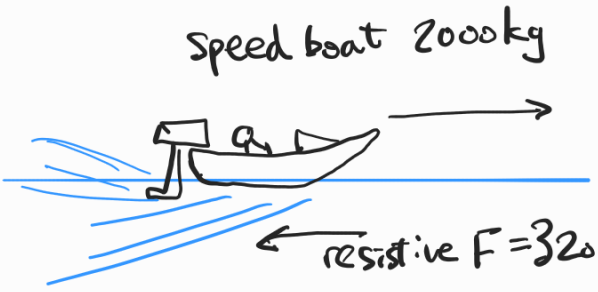
Watt 瓦特

power = $\frac{\text{energy transferred}}{\text{time taken}}$ $P = \frac{E}{t} = \frac{Fs}{t} = Fv$ Unit: W (Js^{-1})

interesting fact: 1 horse power (馬力) = 745W

1000W = 1 kW, 1000 kW = 1 MW

Example



a) Find the power when $v = 10 ms^{-1}$

$P = Fv = 320 \times 10$
$= 3200 W$

b) Find the power of speed boat when it accelerates from zero to $20 ms^{-1}$ in 5s

Displacement $s = \frac{1}{2}(v+u)t = \frac{1}{2}(0+20)(5) = 50m$

Work Done against Fresist: $W_f = fs = 320 \times 50 = 16,000J$

KE gained by speed boat: $\Delta KE = \frac{1}{2}mv^2 = \frac{1}{2}(2000)(20)^2 = 400,000J$

Total work done $W = W_f + \Delta KE = 16,000 + 400,000 = 416,000J$

Power of speedboat: $P = \frac{W}{t} = \frac{416000}{5} = 83200W$ //

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