Conservation of Energy

Four Questions:

1) What is it?

$\boxed{\text{Many different kinds}}$ …

MAG ONLY! E <u>NOT</u> A VECTOR!

a) Kinetic energy

$KE = \frac{1}{2} m V^2$

b) Gravitational potential energy

$PE = m g z$

c) Internal energy

$U = m u$

<u>SPECIFIC</u> INTERNAL E. (PER UNIT MASS)

DUE TO KE, VIBRATIONAL, ROTATIONAL ENERGY, ETC of <u>MOLECULES</u>.

d) Chemical energy → IN BONDS
e) Nuclear energy → IN NUCLEAR BONDS
f) Others…

- ELECTRICAL
- MAGNETIC
- $\boxed{\text{SPRING ENERGY}}$ ← MORE TO COME!

2) How can it be stored? (What is E_{sys}?)

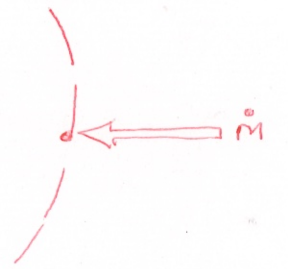
System of particles	Continuum
$E_{sys} = \sum_i m e$	$E_{sys} = \int_{\forall_{sys}} (\rho\, d\forall)\, e$

But, usually….

$$E_{sys} = KE_{sys} + PE_{sys} + U + \ldots$$

3) How can it be transported? (How does it cross system boundaries?)

Flow boundaries



a) Kinetic

rate of KE TRANSPORT: $\frac{\dot{m}V^2}{2} = \dot{m}\frac{V^2}{2}$ = SPECIFIC KE

b) Gravitational potential

rate of PE TRANSPORT $\dot{m}gz$ → SPECIFIC PE

c) Internal

" " I.E. " $(\dot{m})(u)$ OK?!

d) Others

$\dot{m}$ (SPECIFIC OTHER ENERGY)

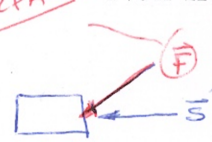
Non-flow boundaries

a) Work

SURFACE F

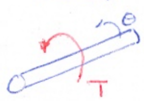
- ONLY F ⊥ TO S
- PATH FUNCTION
- $\neq W_2 - W_1$!!

- MECHANICAL WORK:



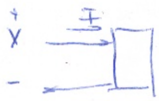
$W_{MECH} = \int_1^2 \vec{F} \cdot d\vec{s}$ | $\dot{W}_{MECH} = \vec{F} \cdot \vec{V}$

- SHAFT



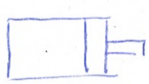
$W_{SH} = \int \vec{T} \cdot d\vec{\theta}$ | $\dot{W}_{SH} = \vec{T} \cdot \vec{\omega}$

- ELECTRICAL



$W_{ELEC} = \int_1^2 V \cdot I \, dt$ | $\dot{W}_{ELEC} = V \cdot I$

- COMPRESSION / EXPANSION



MORE TO COME

$W = \int P \cdot d\forall$ | $\dot{W} = \int P \frac{d\forall}{dt}$

b) Heat transfer

TRANSPORT of ENERGY DUE TO A TEMPERATURE DIFFERENCE ONLY

BETWEEN SYSTEM & SURROUNDINGS!

↳ $\boxed{Q \neq \dot{Q}}$

MORE TO COME!

4) How is it ~~generated~~ and/or ~~consumed~~?

$$\frac{d}{dt}(E_{sys}) = \dot{Q}_{NET,IN} + \dot{W}_{IN,NET} + \sum \dot{m}\left(u + \frac{V^2}{2} + gz + \ldots\right) - \sum \dot{m}\left(u + \frac{V^2}{2} + gz + \ldots\right)$$

NOT FINAL FORM!!

$E_{sys} = KE_{sys} + PE_{sys} + \ldots$