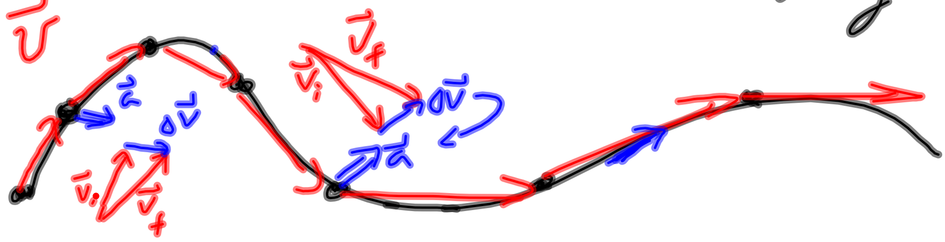
F.B.D. – $\sum \vec{F}_{on\ obj} = \vec{F}_{net} \overset{N2L}{=} m\vec{a}$

def $\uparrow$

$a_c = \frac{v^2}{r}$ — dir — $= \frac{\Delta \vec{v}}{\Delta t}$

mag




speeding up & turning

N3L

$\vec{F}_{A\ on\ B} = -\vec{F}_{B\ on\ A}$

N1L

$\vec{F}_{net} = 0$

$\Leftrightarrow \vec{a} = 0$

$\Leftrightarrow \vec{v} = const$

CG - mech. energy → $\Delta E = W_{nc} \doteq W_{fric} + W_{motor} + W_{N} + W_{T} + \dots$

$W \doteq F d \cos\theta$

(all forces except grav, springs, electrical)

$E \doteq K + U_g + U_s + U_{elec}$

$K$: $\frac{1}{2} m v^2$ — energy of motion

$U_g + U_s + U_{elec}$: energies of arrangement (position)

---

$\Rightarrow \Delta K = W_{net}$ ~ result of N2L

Power $P \doteq \frac{W}{\delta t}$ $\sim W = \frac{J}{s}$

Efficiency (simple machines) $\epsilon \doteq \frac{W_{out\ of\ mach}}{W_{in\ mach}}$

$\epsilon_{heat\ engine} < \frac{T_H - T_c}{T_H}$

p544

1st Law of Thermo $\Delta U = Q + W$

internal energy

heat added to sys

work done on system

$\Delta U = mC\Delta T$

If sys = gas,

$W = -P\Delta V$ (pressure, volume)

$\bar{K} = \frac{3}{2} k_B T$

$k_B = 1.38E\text{-}23 \frac{J}{K} = \frac{R}{N_A} \approx \frac{8.314 \text{ J/mol K}}{6E23 \text{ atoms/mol}} \approx \frac{.0821 \frac{L \cdot atm}{mol\,K}}{6E23}$

Dec 9-8:20 AM

Heat (Q) flow takes time

- cond - $P = A k \frac{\Delta T}{d}$ ~ W ($m^2$)
- conv - fluid
- rad - $P = A \epsilon \sigma_{SB} T^4$ ~ W
  (EM ~)
  - light - μwave ... IR - ROYGBV - UV - X-ray - γ-ray
  (μwave … IR: RJ; IR … UV: stars; X-ray … γ-ray: H-bombs)

Always ∥ $T_{Hotter} \rightarrow T_{Colder}$

density $\rho \doteq \frac{M}{V} \sim \frac{kg}{m^3}$

$\rho_{H_2O} = 1000\ kg/m^3 = 1\ gm/cm^3$

$\rho_{brass} = 8900$ " $= 8.9$ "

---

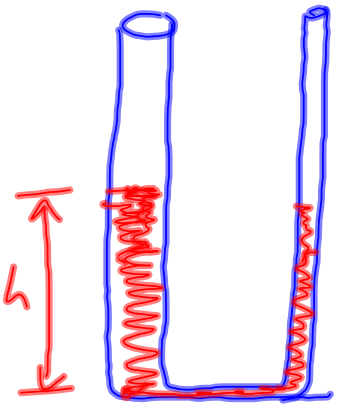
pressure $P \doteq \frac{F}{A} \sim \frac{N}{m^2} = Pa$

$1\ atm = 760\ Torr = 14.7 \frac{lb}{in^2} = 101.3\ kPa$

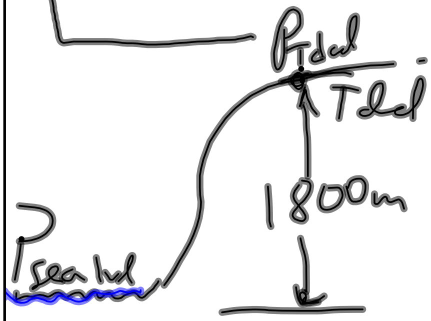
In a fluid (liquid or gas),

$\Delta P = \rho g h$

(static only)




$610\ Torr \left(\frac{101.3\ kPa}{760\ Torr}\right) = 81.3\ kPa$




$P_{SL} - P_{Tdel} = \rho g h$

$101.3\ kPa - 81.3 = \rho_{air} (9.8 \frac{m}{s^2})(1800 m)$

$1.13 \frac{kg}{m^3} = \frac{20\,000\ Pa}{(9.8 \frac{m}{s^2})(1800 m)} = \rho_{air}$

T 1.0 $kg/m^3$
SL 1.3 "

$\frac{Pa\ s^2}{m^2} = \frac{N}{m^2} \frac{s^2}{m^2} = \frac{kg\ m}{s^2} \frac{s^2}{m^4} = \frac{kg}{m^3}$

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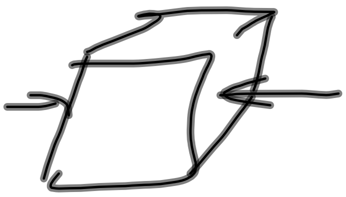
☆ Buoyant force $= \rho_{fluid}\, g\, V_{displ.}$

$$PV = NkT = nRT \sim J$$

$$\underbrace{Pa \cdot m^3}_{J} = \#\left(1.38E{-}23 \frac{J}{\# K}\right) K = mol\left(8.31 \frac{J}{mol\, K}\right) K$$

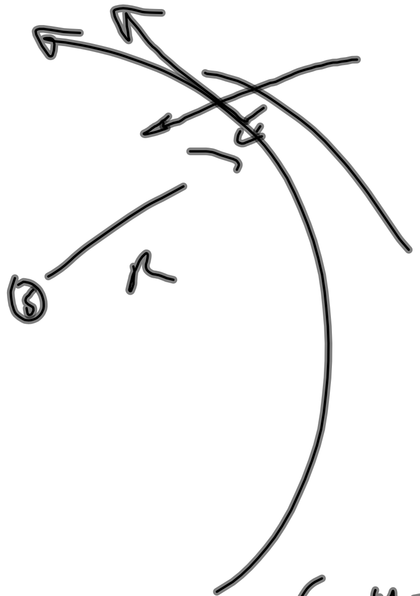
Example ~ 7m dia asteroid falling to Earth

$7\,m \sim dia \qquad \underline{V} \sim 350\ m^3$



$\rho_{ast} \sim 9000\ kg/m^3$

$M = \rho \underline{V} = 3.1\ M\ kg$




$V_E \cong 30\ km/s \approx V_{asteroid}$

$K = \frac{1}{2} M v^2 \sim \frac{1}{2}(3.1\ M\ kg)(3E4\ \frac{m}{s})^2$

$= 1.5E19\ J$

$\left(\frac{1\ gal\ gas}{130\ MJ}\right)$

114 G gal gas

$C_m^{mt}$

$1.5E19\ J \left(\frac{1\ \text{megaton TNT}}{4.2E15\ J}\right) = 3500\ \text{Mton}!$

$$\epsilon_{new\ tech} > \epsilon_{theoretical\ max} = 1 - \frac{T_C}{T_H}$$

impossible

$T \leq 0\,K$ – physically impossible

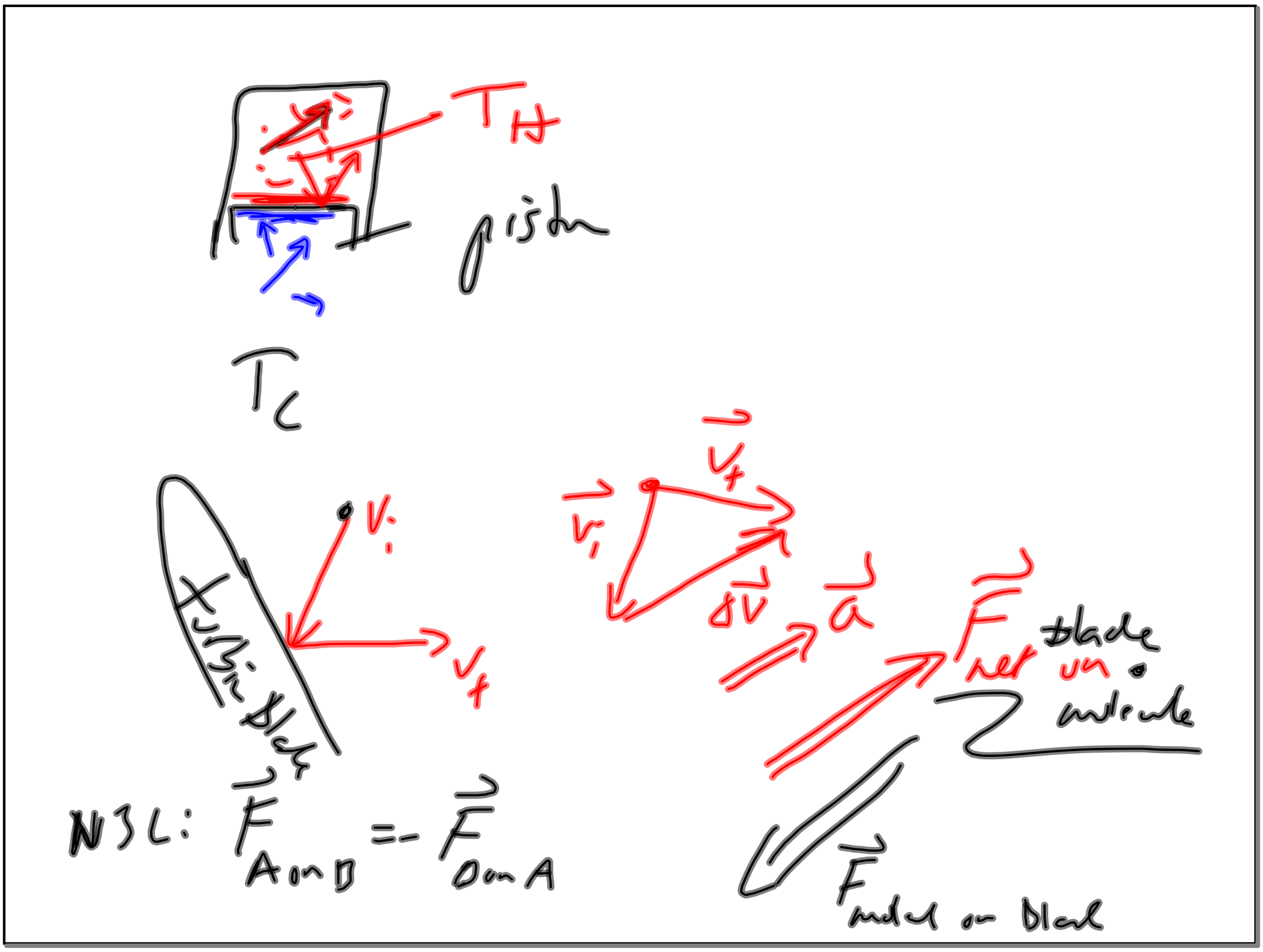
$+ .06\,\mu K$

Automobile $T_C = 100°C = 373\,K$

$T_H = 1500°C = 1773\,K$

carnot eff $= \epsilon = 1 - \frac{373}{1773} = .79$

Dec 12-8:15 AM


T_H
piston
T_C
v_i
v_f
turbine blade
N3L: F_A on B = - F_B on A
δv
a
F_net blade on molecule
F molecule on blade