L10

Momentum $\vec{P} = \sum \vec{P_i}$

conservation of momentum (3rd Law)

$\dot{\vec{P}} = \vec{F}_{ext}$ $\qquad$ $\vec{P} = const$ if $\vec{F}_{ext} = 0$

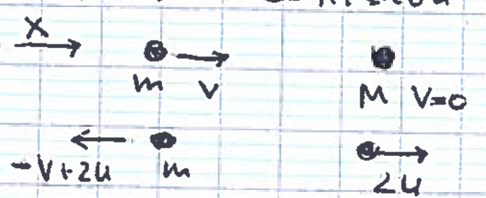
– inelastic collision. (Kinetic energy is not conser[ved])

$\vec{P} = m_1\vec{v}_1 + m_2\vec{v}_2$ before

$\vec{P} = (m_1 + m_2)\vec{V}$ after $\Big\} \rightarrow V = \dfrac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_1 + m_2}$

if one body is at rest $v_2 = 0 \rightarrow V = \dfrac{m_1\vec{v}_1}{m_1 + m_2}$

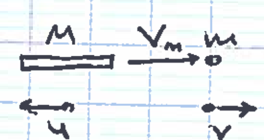
– elastic collision (energy is conserved)



constrain to 1D motion along x axis.

$u = \dfrac{mv}{M+m}$ after collision.

– Gun & bullet : in the range ref. frame.



in the range ref. frame.

$M\vec{u} = -m\vec{v}$

$|V_m| = |u| + |v|$

$Mu = m(V_m - u)$ $\qquad$ $u = mV_m/(m+M)$

velocity of the gun in range frame

* Rockets

rocket is loosing a small amount of mass dm – negative ejected with V_m in the rocket ref. frame.

$P(t+dt) = (m + dm)(v + dv) - dm\,(v - V_m) =$

$= mv + dm\,v + m\,dv + dm\,dv - dm\,v + dm\,V_m$ (with $mv = P(t)$)

$dP = P(t+dt) - P(t) = m\,dv + dm\,V_m$

$dP = 0$ $\qquad$ $m\,dv = -dm\,V_m \rightarrow m\dot{v} = -\dot{m}V_m$

thrust $= -\dot{m}V_m$

$dv = -V_m\,dm/m \rightarrow v - v_0 = V_m \ln \dfrac{m_0}{m}$

need a lot of fuel, because most of thrust is used to accelerate fuel.

$\dfrac{v - v_0}{V_m} = \ln\dfrac{m_0}{m} \sim 2.3$ for $m_0/m = 10$