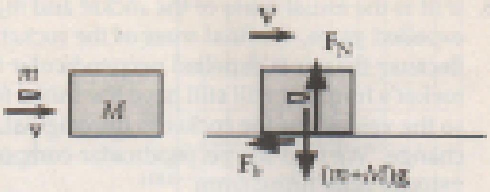
8. On the horizontal surface after the collision, the normal force is $F_N = (m + M)g$.
We find the common speed of the block and bullet immediately after the embedding by using the work-energy principle for the sliding motion:



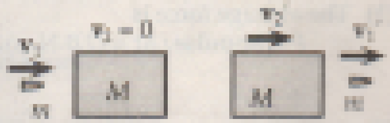

$W_{fr} = \Delta KE$;
$-\mu_k(m + M)gd = 0 - \frac{1}{2}(M + m)V^2$;
$0.25(9.80\ \mathrm{m/s^2})(9.5\ \mathrm{m}) = \frac{1}{2}V^2$, which gives $V = 6.82\ \mathrm{m/s}$.

For the collision, we use momentum conservation:
$mv + 0 = (M + m)V$;
$(0.015\ \mathrm{kg})v = (0.015\ \mathrm{kg} + 1.10\ \mathrm{kg})(6.82\ \mathrm{m/s})$, which gives $\boxed{v = 5.1 \times 10^2\ \mathrm{m/s}.}$

9. The new nucleus and the alpha particle will recoil in opposite directions.
Momentum conservation gives us
$0 = MV - m_\alpha v_\alpha$;
$0 = (57m_\alpha)V - m_\alpha(3.8 \times 10^5\ \mathrm{m/s})$, which gives $V = \boxed{6.7 \times 10^3\ \mathrm{m/s}.}$

10. Because mass is conserved, the mass of the new nucleus is $M_2 = 222\ \mathrm{u} - 4.0\ \mathrm{u} = 218\ \mathrm{u}$.
Momentum conservation gives us
$M_1V_1 = M_2V_2 + m_\alpha v_\alpha$;
$(222\ \mathrm{u})(420\ \mathrm{m/s}) = (218\ \mathrm{u})(350\ \mathrm{m/s}) + (4.0\ \mathrm{u})v_\alpha$, which gives $v_\alpha = \boxed{4.2 \times 10^3\ \mathrm{m/s}.}$

11. Momentum conservation gives us
$mv_1 + Mv_2 = mv_1' + Mv_2'$;
$(0.013\ \mathrm{kg})(230\ \mathrm{m/s}) + 0 = (0.013\ \mathrm{kg})(170\ \mathrm{m/s}) + (2.0\ \mathrm{kg})v_2'$,
which gives $v_2' = \boxed{0.39\ \mathrm{m/s}.}$




12. (a) With respect to the Earth after the explosion, one section will have a speed $v_1'$ and the other will have a speed $v_2' = v_1' + v_{\text{relative}}$. Momentum conservation gives us
$mv = \frac{1}{2}mv_1' + \frac{1}{2}mv_2'$, or
$v = \frac{1}{2}v_1' + \frac{1}{2}(v_1' + v_{\text{relative}}) = v_1' + \frac{1}{2}v_{\text{relative}}$
$5.80 \times 10^3\ \mathrm{m/s} = v_1' + \frac{1}{2}(2.20 \times 10^3\ \mathrm{m/s})$, which gives $v_1' = \boxed{4.70 \times 10^3\ \mathrm{m/s}.}$
The other section will have
$v_2' = v_1' + v_{\text{relative}} = 4.70 \times 10^3\ \mathrm{m/s} + 2.20 \times 10^3\ \mathrm{m/s} = \boxed{6.90 \times 10^3\ \mathrm{m/s}.}$
(b) The energy supplied by the explosion increases the kinetic energy:
$E = \Delta KE = [\frac{1}{2}(\frac{1}{2}m)v_1'^2 + \frac{1}{2}(\frac{1}{2}m)v_2'^2] - \frac{1}{2}mv^2$
$= [\frac{1}{2}(\frac{1}{2}975\ \mathrm{kg})(4.70 \times 10^3\ \mathrm{m/s})^2 + \frac{1}{2}(\frac{1}{2}975\ \mathrm{kg})(6.90 \times 10^3\ \mathrm{m/s})^2] - \frac{1}{2}(975\ \mathrm{kg})(5.80 \times 10^3\ \mathrm{m/s})^2$
$= \boxed{5.90 \times 10^8\ \mathrm{J}.}$