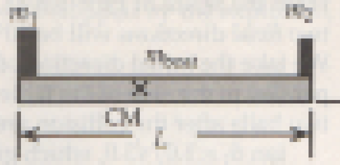
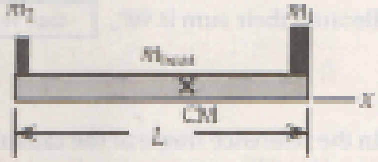
70. We choose the origin of our coordinate system at the initial position of the 75-kg person. For the location of the center of mass of the system we have



$x_{CM} = (m_1x_1 + m_2x_2 + m_{boat}x_{boat})/(m_1 + m_2 + m_{boat})$
$= [(75\text{ kg})(0) + (60\text{ kg})(2.0\text{ m}) + (80\text{ kg})(1.0\text{ m})]/(75\text{ kg} + 60\text{ kg} + 80\text{ kg}) = 0.93\text{ m}.$

Thus the CM will be 2.0 m – 0.93 m = 1.07 m from the 60-kg person. When the two people exchange seats, the CM will not move. The end where the 75-kg person started, which was 0.93 m from the CM, is now 1.07 m from the CM, that is, the boat must have moved 1.07 m – 0.93 m =



0.14 m toward the initial position of the 75-kg person.

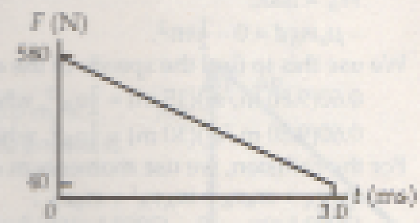
71. (*a*) We take the direction of the meteor for the positive direction.
For this perfectly inelastic collision, we use momentum conservation:
$M_{meteor}v_{meteor} + M_{Earth}v_{Earth} = (M_{meteor} + M_{Earth})V;$
$(10^8\text{ kg})(15 \times 10^3\text{ m/s}) + 0 = (10^8\text{ kg} + 6.0 \times 10^{24}\text{ kg})V$, which gives $\boxed{V = 2.5 \times 10^{-13}\text{ m/s}.}$

(*b*) The fraction transformed was
$\text{fraction} = \Delta KE_{Earth}/KE_{meteor} = \frac{1}{2}m_{Earth}V^2/\frac{1}{2}m_{meteor}v_{meteor}^2$
$= (6.0 \times 10^{24}\text{ kg})(2.5 \times 10^{-13}\text{ m/s})^2/(10^8\text{ kg})(15 \times 10^3\text{ m/s})^2 = \boxed{1.7 \times 10^{-17}.}$

(*c*) The change in the Earth's kinetic energy was
$\Delta KE_{Earth} = \frac{1}{2}m_{Earth}V^2$
$= \frac{1}{2}(6.0 \times 10^{24}\text{ kg})(2.5 \times 10^{-13}\text{ m/s})^2 = \boxed{0.19\text{ J}.}$

72. Momentum conservation gives
$0 = m_1v_1' + m_2v_2'$, or $v_2'/v_1' = -m_1/m_2$.
The ratio of kinetic energies is
$KE_2/KE_1 = \frac{1}{2}m_2v_2'^2/\frac{1}{2}m_1v_1'^2 = (m_2/m_1)(v_2'/v_1')^2 = 2.$
When we use the result from momentum, we get
$(m_2/m_1)(-m_1/m_2)^2 = 2$, which gives $m_1/m_2 = \boxed{2}$

73. (*b*) The force would become zero at
$t = 580/(1.8 \times 10^5) = 3.22 \times 10^{-3}\text{ s}.$
At $t = 3.0 \times 10^{-3}$ s the force is
$580 - (1.8 \times 10^5)(3.0 \times 10^{-3}\text{ s}) = +40\text{ N}.$
The impulse is the area under the F vs. t curve, and consists of a triangle and a rectangle:



$\text{Impulse} = \frac{1}{2}(580\text{ N} - 40\text{ N})(3.0 \times 10^{-3}\text{ s}) + (40\text{ N})(3.0 \times 10^{-3}\text{ s}) = \boxed{0.93\text{ N}\cdot\text{s}.}$

(*c*) We find the mass of the bullet from
$\text{Impulse} = \Delta p = m\,\Delta v;$
$0.93\text{ N}\cdot\text{s} = m(220\text{ m/s} - 0)$, which gives $m = 4.23 \times 10^{-3}\text{ kg} = \boxed{4.2\text{ g}}$