1a.

$m \cdot v_0 = (101m) \cdot v$

$v = \frac{v_0}{101}$

1b.

$\Delta K = K_f - K_i$

$= \frac{1}{2}(101m)(\frac{v_0}{101})^2 - \frac{1}{2}mv_0^2$

$= -\frac{50}{101} mv_0^2$

1c.

$\Delta t_{descent} = \sqrt{\frac{2h}{g}}$

$x = \frac{v_0}{101} \cdot \sqrt{\frac{2h}{g}}$

1d. The time of descent is independent of the block's speed because the initial velocity in the y-dimension is always zero as the block slides off the table.

1e. The distance will be lesser because the block's velocity will be lesser. By conservation of momentum, if the bullet passes through the block, it will have a lesser negative change in momentum, meaning the block will have a lesser positive change in momentum.

2a.

$mgR = \frac{1}{2}mv^2$

$v = \sqrt{2gR}$

2b.

$m \cdot \sqrt{2gR} = 2m \cdot v$

$v = \frac{\sqrt{2gR}}{2} = \sqrt{\frac{gR}{2}}$

2c.

$$\begin{aligned}\Delta K &= K_f - K_i \\ &= \frac{1}{2}(2m)\left(\sqrt{\frac{gR}{2}}\right)^2 - \frac{1}{2}m\left(\sqrt{2gR}\right)^2 \\ &= -\frac{gRm}{2}\end{aligned}$$

2d.

$$\begin{aligned}E_{th} &= -W_{kf} \\ &= -(F_{kf})(\Delta s)(\cos\theta) \\ &= -(\mu \cdot 2mg)(L)(\cos 180^\circ) \\ &= 2\mu mgL\end{aligned}$$

2e. If the masses were greater, the normal force would be greater and this would create a greater negative force of kinetic friction, tending to slow the blocks down more quickly. If the masses were greater, they would have a greater resistance to being accelerated by Newton's second law, tending to slow the blocks down less quickly.

3a.

$p_i = 3M \cdot v_0 + M \cdot v_0 = 4M \cdot v_0$

3b.

$4M \cdot v_0 = (2M) \cdot v$

$v = 2 \cdot v_0$ to the right

3c.

$4M \cdot v_0 = (M)(2.5v_0) + (M)(v_a)$

$v_a = 1.5v_0$ to the right

3d.

$\Delta K = K_f - K_i$

$= [½(M)(2.5v_0)^2 + ½(M)(1.5v_0)^2] - [½(M)(3v_0)^2 + ½(M)(1v_0)^2]$

$= -\frac{3}{4} M \cdot v_0^2$

4a.

Cart A while accelerating:

$\Delta s = 7$ $v_{avg} = 3.5$

$v_i = 2$ $a = 1.5$

$v_f = 5$ $\Delta t = 2$

Cart A while coasting:

$\Delta s = 8$

$v = 5$

$\Delta t = 1.6$

So the total time is 3.6s

4b.

$(250)(5) = (200)(4.8) + (250)(v)$

$v = 1.16$m/s to the right

4c.

$$\begin{aligned}\Delta K &= K_f - K_i \\ &= \tfrac{1}{2}(200)(4.8^2) + \tfrac{1}{2}(250)(1.16^2) - \tfrac{1}{2}(250)(5^2) \\ &= -652.8\text{J}\end{aligned}$$

There is a change in kinetic energy, so the collision is not elastic.

5a.

$p_i = p_f$

$0 = (70)(-0.550) + (35)(v_{son})$

$v_{son} = 1.1m/s$

5b.

$F = ma$

$= (35)(\frac{1.1-0}{0.6}) = 64.2N$

5c. By Newton's third law, the force of the son on the mother is equal in magnitude, but opposite in direction, to the force of the mother on the son.

5d. Both accelerations have a magnitude of $\mu \cdot g$, which is the same for both. Therefore, if the son has twice the initial velocity, he will travel four times farther, 28m.

$v_f^2 = v_i^2 + 2(a)(\Delta s)$

6a.

$(3M)gH = \frac{1}{2}(3M)v_b^2$

$v_b = \sqrt{2gH}$

6b.

$p_i = p_f$

$(3M)(+v_b) + (M)(-v_b) = (M)(v_s) + (3M)(V_l)$

6c.

$(3M)(+v_b) + (M)(-v_b) = (M)(v_s) + 0$

$v_s = 2v_b$

6d.

$$\begin{aligned}\Delta K &= K_f - K_i \\ &= \frac{1}{2}(M)(2v_b)^2 - [\frac{1}{2}(3M)(v_b^2) + \frac{1}{2}(M)(v_b^2)] = 0\end{aligned}$$

The collision is elastic because there is no change in kinetic energy

6e.

$\frac{1}{2}(M)(2v_b)^2 = Mgh$ where $v_b = \sqrt{2gH}$

$h = 4H$