22. \( m_1 = 2 \text{ kg} \quad m_2 = 1 \text{ kg} \)
\( a_1 = 10 \text{ m/s}^2 \quad a_2 = ? \)

The forces acting on the two particles are equal and opposite according to Newton's Third Law. Thus, the accelerations are in inverse proportion to the masses according to Newton's Second Law. So,

\[
\frac{m_1 \vec{a}_1}{m_2 \vec{a}_2} = \frac{F_1}{F_2} = \frac{-F_2}{-F_2} = 1
\]

Taking the scalar component along the N-S axis with North positive,

\[
a_2 = -\frac{m_1}{m_2} a_1
\]

\[
= -\frac{2 \text{ kg}}{1 \text{ kg}} \times 10 \text{ m/s}^2 = -20 \text{ m/s}^2
\]

The minus indicates direction South.
Using strict vector notation, establish

\( a_y = \mathbf{a}_y \hat{j} \quad (= 10 \text{ m/s}^2 \hat{j}) \)

\[ a_n = -\frac{m_1}{m_n} a_y \hat{j} \]

\[ = -70 \text{ m/s}^2 \hat{j} \]

34. 

Blood \hspace{1cm} Heart + Everything Else

\[ F_b \leftarrow m_B - m_H \rightarrow F_H \]

\( m_T = 2 \text{ kg} \)

\( m_B = 70 \text{ kg} \)

\( \Delta \tau = 0.1 \text{ sec} \)

\( a_H = 0.06 \text{ m/s}^2 \)

\( m_H = m_B + m_T \)

\( F_H = ? \)

The interaction between the blood and the heart on ventricular contraction ejects blood into the aorta. The acceleration of the blood \( \mathbf{a}_B \) is due to a force \( F_B \) exerted on it by the heart. By NTH, the heart suffers
a reaction force

\[ \vec{F}_H = - \vec{F}_B \]

The force is transmitted to the entire body and to ballistic cardiograph tube.

By NII,

\[ m_H \vec{a}_H = \vec{F}_H = - \vec{F}_B = - m_B \vec{a}_B \]

The force exerted by the heart is the force on the blood \( F_B \)

\[ F_B = - m_H \vec{a}_H \]

\[ = - (m_p + m_t) \vec{a}_H \]

\[ = - (70 \text{ kg} + 2 \text{ kg}) \times 0.06 \text{ m/s}^2 \]

\[ = - 4.3 \text{ N} \quad (a \text{ pound} !!) \]

The minus sign indicates that the force by the heart on the blood is in the opposite direction from the detected acceleration which is due to the force of the blood acting on the heart.
b). The change in momentum $\Delta p$ is
the impulse provided by the interaction
between heart and blood.

$$\Delta p = F \Delta t$$

$$= -F_B \Delta t$$

$$= (m_p + m_B) \Delta t$$

$$= (70 \text{ kg} + 20 \text{ kg}) \times 0.06 \text{ m/s}^2 \times 0.1 \text{ sec}$$

$$= 0.43 \text{ kg-m/s}$$

Again, the plus sign indicates that the
momentum change computed -- the momentum
change of the heart plus everything else -- is
in the same direction as the measured
acceleration.

(There's ambiguity in the question, so
the signs could be opposite depending
on how you interpret the question
and what coordinate system you choose.)
35. \[ m_B = 6.7 \times 10^{-3} \text{ kg} \]
\[ m_C = \text{N/A} \]
\[ v_C = 350 \text{ m/s} \]
\[ l = 0.24 \text{ m} \]

By III
\[ \vec{F}_C = \vec{F}_B \]

By I
\[ -m_C \vec{a}_C = -\vec{F}_C = \vec{F}_B = m_B \vec{a}_B \]

We don't know \( m_C \) and we don't know \( a_B \) so we don't have enough info to compute the acceleration or the force.

The problem is that even with our knowledge of the muzzle velocity, we don't know how far the bullet traveled inside the recoiling barrel as seen from the CM frame.

So... we'll make the reasonable assumption that the experiment was carried out with the gun mounted in a test clamp so that
effectively the mass of the gun is the mass of the Earth and essentially infinite. In this case the recoil acceleration of the gun in the CM frame is

$$a_G = \frac{F_G}{m_G} = 0$$

Under this assumption, the distance traveled by the bullet to the muzzle is \(l\). Now we have

$$F_B = m_B a_B$$

and all we need is to get the acceleration \(a_B\) from the kinematics of a constant acceleration (the average acceleration) through a known distance to a known final velocity.

$$v_{Bf} = a_B t$$

We need \(t\), but

$$l = \frac{1}{2} a_B t^2$$

so
\[ t = \sqrt{\frac{2L}{a_B}} \quad \text{(look familiar?)} \]

and

\[ v_{Bf} = a_B \sqrt{\frac{2L}{a_B}} = \sqrt{2a_B L} \quad \text{(look familiar?)} \]

Solving for \( a_B \) gives

\[ a_B = \frac{v_{Bf}^2}{2L} \quad \text{(an equation many have memorized)} \]

And finally,

\[ F_B = m_B a_B = \frac{m_B v_{Bf}^2}{2L} \]

\[ = \frac{m_B v_{Bf}^2}{2L} = \frac{6 \times 10^{-3} \, \text{kg} \times (350 \, \text{m/s})^2}{2 \times 24 \times 10^{-5} \, \text{m}} = N \]

\[ = 13500 \, \text{N} = 13.5 \, \text{kN} \]

\[ \text{N.B.} \quad F_B = \frac{1}{2} m_B v_{Bf}^2 \]

or

\[ F_B L = \frac{1}{2} m_B v_{Bf}^2 \]

Work Done \( \rightarrow \) Kinetic Energy
92.

\[ m = 6 \times 10^{-3} \text{ kg} \]
\[ v_0 = 1 \times 10^2 \text{ m/s} \]
\[ \Delta t = 6 \times 10^{-4} \text{ sec} \]

\[ \begin{array}{c}
F \\ \\
\downarrow \\
\leftarrow m \\
\uparrow \\
F_0
\end{array} \]

\[ F = ? \]

Initial momentum is
\[ p_0 = m \cdot v_0 \]

Final momentum is \( p_f = 0 \)

So
\[ \Delta p = -m \cdot v_0 \]

Impulse is
\[ F \Delta t = \Delta p \]

\[ F = \frac{\Delta p}{\Delta t} \]

(Could start here)

(Call it \( N \))

\[ = -6 \times 10^{-3} \text{ kg} \times 1 \times 10^2 \text{ m/s} \]

\[ = -6 \times 10^{-4} \text{ N} \]

\[ = -1 \times 10^3 \text{ N} = 1 \text{ kN} \]

Minus sign means Force is opposite initial velocity.
Less elegant approach:

- \( F = ma \)  
- \( v_f = v_0 + at \)  
- \( v_0 = -at \)  
- \( a = \frac{-v_0}{t} \)  
- \( F = -\frac{m \Delta v}{\Delta t^2} \)
44. \[ F = F_T - mg \]
\[ = Ct - mg \]
\[ a(t) = ? \]
\[ v(t) = ? \]
\[ v(0) = 0 \]

**N II:**
\[ F(t) = ma(t) \]
\[ a(t) = \frac{F(t)}{m} \]
\[ = \frac{Ct - mg}{m} \]
\[ a(t) = \frac{C}{m}t - g \]

\[ a(t) = \frac{dv(t)}{dt} \]
\[ v(t) = \int a(t) \, dt \]
\[ = \int \left( \frac{C}{m}t - g \right) \, dt \]
\[ = \frac{C}{m} \int t \, dt - \int g \, dt \]
\[ = \frac{C}{2m} t^2 - gt + K \]
\[ a(t) = 0, \quad v(0) = 0 \]
\[ \Rightarrow 0 = 0 + K \]
\[ \Rightarrow K = 0 \]
\[ v(t) = \frac{C}{2m} t^2 - gt \]