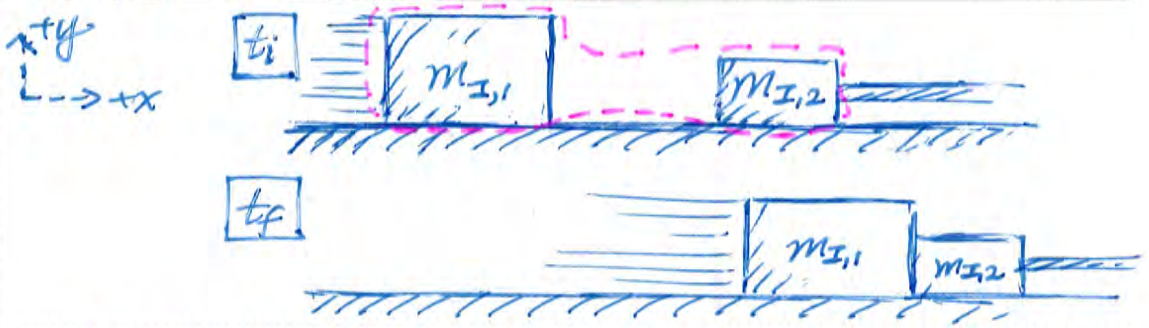
Title

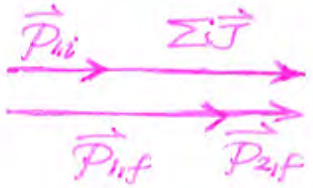
Impulse-momentum theorem

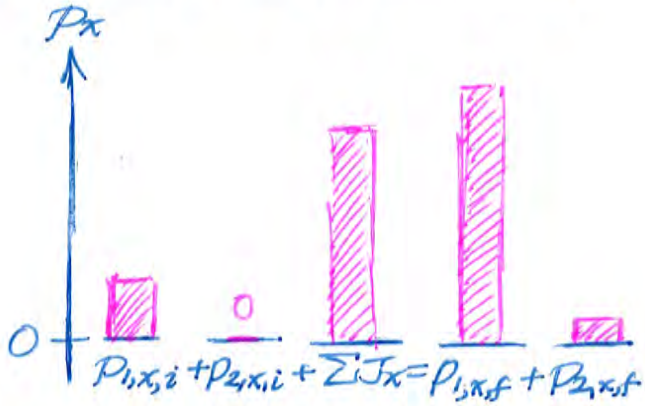
Ingredients

Sketch	
At/Through	$[t_i, t_f]$ t_i t_f
Owner	System
Quantity	Net impulse; Total momentum
Variable	$\Sigma\vec{J}$, ΣJ_x, ΣJ_y; $\Sigma\vec{p}_i$, $\Sigma p_{x,i}$, $\Sigma p_{y,i}$; $\Sigma\vec{p}_f$, $\Sigma p_{x,f}$, $\Sigma p_{y,f}$
Giver	External environment

Recipe

Diagram the relationship	ΣJ_x; $\Sigma p_{x,i}$ → $\Sigma p_{x,f}$
Graphically present quantities	Impulse-momentum vector-addition diagram; x-impulse-x-momentum bar chart
Mathematical relationship	$\Sigma\vec{p}_i + \Sigma\vec{J} = \Sigma\vec{p}_f$; $\Sigma p_{x,i} + \Sigma J_x = \Sigma p_{x,f}$ $\Sigma p_{y,i} + \Sigma J_y = \Sigma p_{y,f}$





Page M3
Title: Impulse-momentum theorem

The top half of this sheet consists of an "**Ingredients**" section with a row labeled "Sketch", a row labeled "At/Through", a row labeled "Owner", a row labeled "Quantity", a row labeled "Variable", and a row labeled "Giver."

Sketch: Initial time t-sub-i: Two blocks are on a horizontal surface. Block 1 at the left is larger and labeled m-sub-I,1. Block 2, at the right, is labeled m-sub-I,2. Whooshies trail to the left behind block 1, indicating that block 1 is in the midst of moving toward the right. Block 2, which is momentarily at rest, is being pulled toward the right by a taut rope.

Final time t-sub-f: The blocks, still labeled m-sub-I,1 and m-sub-I,2 as in the initial snapshot, are still on the surface, though positioned farther to the right. The blocks are in contact and moving together toward the right, with block 1 still to the left of block 2. The whooshies trailing to the left behind block 1 are longer than in the initial snapshot, indicating a greater speed. The rope pulling block 2 toward the right is still taut.

Dashed axis arrows indicate that +x points toward the right and +y points up the page.

Remaining rows of Ingredients section are used for a flowchart illustrating the following:
The Owner is the System. Through the interval from initial time t-sub-i to final time t-sub-f, the System accrues the Quantity Net impulse associated with Variables Sigma-J-vector, Sigma-J-sub-x, and Sigma-J-sub-y given by Giver External environment. At initial time t-sub-i, the System owns the Quantity Initial total momentum associated with Variables Sigma-p-vector-sub-i, Sigma-p-sub-x,i, and Sigma-p-sub-y,i. At final time t-sub-f, the System owns the Quantity Final total momentum associated with Variables Sigma-p-vector-sub-f, Sigma-p-sub-x,f, and Sigma-p-sub-y,f.

The bottom half of this sheet consists of a "**Recipe**" section with a row labeled "Diagram the relationship", a row labeled "Graphically present quantities", and a row labeled "Mathematical relationship".

Diagram the relationship
A flowchart arrow shows that initial total x-momentum Sigma-p-sub-x,i contributes to final total x-momentum Sigma-p-sub-x,f. Another arrow shows that net x-impulse Sigma-J-sub-x also contributes to final total x-momentum Sigma-p-sub-x,f.

Graphically present quantities
Title of first section: Impulse-momentum vector-addition diagram
Draw an arrow pointed to the right labeled p-vector-sub-1,i. From the head of this arrow, draw a longer arrow also pointed toward the right labeled Sigma-J-vector. Immediately underneath the two arrows just now drawn, draw another pair of arrows, also touching in a head-to-tail fashion, and also both pointing horizontally to the right. The arrow at the left is longer and labeled p-vector-sub-1,f. The arrow at the right is labeled p-vector-sub-2,f. The two rows of vectors are equally wide and horizontally centered together.

Title of second section: x-impulse-x-momentum bar chart
Plot p-sub-x on the vertical axis. Draw a tickmark labeled 0. At the height of this tickmark, draw five horizontal segments to the right, with one segment each above each of the terms of the labeling equation p-sub-1,x,I + p-sub-2,x,I + Sigma-J-sub-x = p-sub-1,x,f + p-sub-2,x,f. From the segment above the term p-sub-1,x,i, extend upward a short, shaded rectangular bar. Write the number 0 above the segment above the term p-sub-2,x,i. From the segment above the term Sigma-J-sub-x, extend upward a tall, shaded rectangular bar. From the segment above the term p-sub-1,x,f, extend upward an even taller shaded rectangular bar. From the segment above the term p-sub-2,x,f, extend upward a short, shaded rectangular bar. Scale the heights of the bars so that the sum of the heights of the bars for the terms p-sub-1,x,i and Sigma-J-sub-x equals the sum of the heights of the bars for the terms p-sub-1,x,f and p-sub-2,x,f.

Mathematical relationship
Sigma-p-vector-sub-i + Sigma-J-vector = Sigma-p-vector-sub-f
Sigma-p-sub-x,i + Sigma-J-sub-x = Sigma-p-sub-x,f
Sigma-p-sub-y,i + Sigma-J-sub-y = Sigma-p-sub-y,f