

Title

Impulse delivered by a force

MI

Ingredients

Sketch



At/Through



Owner



Quantity



Variable

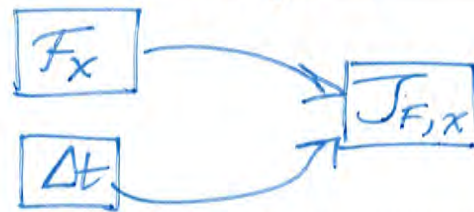


Giver

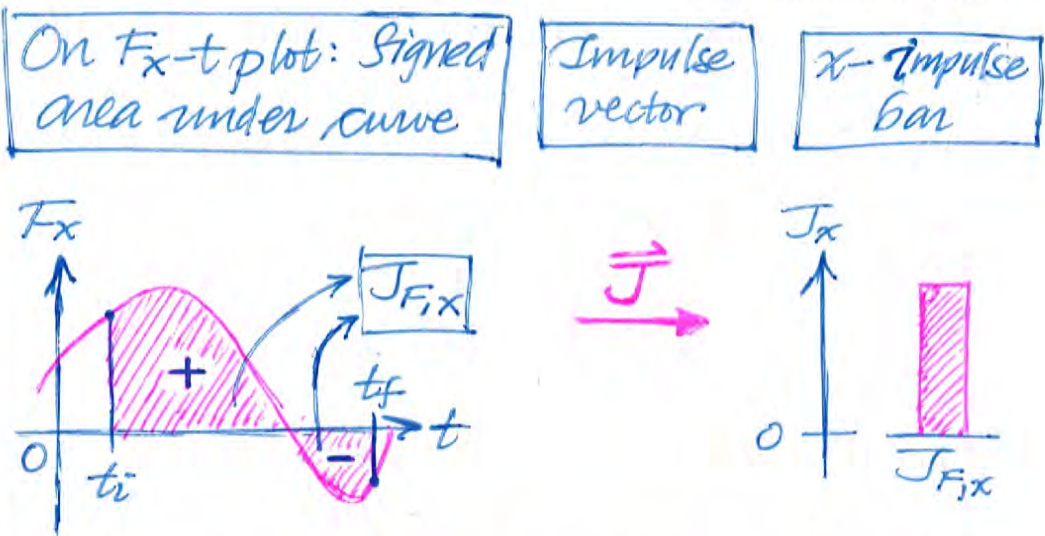


Recipe

Diagram the relationship



Graphically present quantities



Mathematical relationship

Signed area between  $F_x-t$  plot and  $t$  axis =  $J_{Fx}$

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: In a snapshot at the left, a block is sliding across a horizontal floor toward the right, as indicated by whooshies trailing at the left. A taut rope is pulling on the block toward the right. A dashed bubble surrounding the block indicates the block is the system. Another snapshot of the block toward the right with trailing whooshies show that the block is still moving toward the right. The taut rope is still pulling on the block toward the right. 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:

There are two Owners: the System and the Frame. At time  $t$ , the System receives the Quantity Force associated with Variables  $F$ -vector,  $F$ -sub- $x$ , and  $F$ -sub- $y$ , given by Giver External agent. Through the course of the interval from initial time  $t$ -sub- $i$  to final time  $t$ -sub- $f$ , the System accrues the Quantity Impulse associated with Variables  $J$ -vector-sub- $F$ ,  $J$ -sub- $F,x$ , and  $J$ -sub- $F,y$ , given by Giver External agent. Through the course of the interval from initial time  $t$ -sub- $i$  to final time  $t$ -sub- $f$ , the Frame, meaning frame of reference, accrues the Quantity Elapsed duration denoted by the Variable  $\Delta t$ .

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  $x$ -force  $F$ -sub- $x$  contributes to  $x$ -impulse  $J$ -sub- $F,x$ . Another arrow shows that elapsed duration  $\Delta t$  also contributes to  $x$ -impulse  $J$ -sub- $F,x$ .

Graphically present quantities

Title of first section: On  $F$ -sub- $x$ - $t$  plot: Signed area under curve

Plot  $x$ -force  $F$ -sub- $x$  along the vertical axis. Plot time  $t$  along the horizontal axis. Draw a generic graph of a function with some positive and negative values. Draw tickmarks for initial time  $t$ -sub- $i$  and final time  $t$ -sub- $f$  on the time axis so that the interval between these times includes times when the  $x$ -force is positive and times when the  $x$ -force is negative. Draw vertical segments extending from the tickmarks on the time axis to the graph. Shade the region between the  $F$ -sub- $x$ - $t$  plot and the  $t$ -axis between initial time  $t$ -sub- $i$  and final time  $t$ -sub- $f$ . Within each shaded region above the time axis, write a positive sign. Within each shaded region below the time axis, write a negative sign. Draw arrows originating from each such shaded region and pointing toward a caption box for the  $x$ -impulse, labeled  $J$ -sub- $F,x$ .

Title of second section: Impulse vector

Draw an arrow pointing toward the right labeled  $J$ -vector.

Title of third section:  $x$ -impulse bar

Plot  $J$ -sub- $x$  on the vertical axis. Draw a tickmark labeled 0. At the height of this tickmark, draw a horizontal segment to the right, labeled underneath as  $J$ -sub- $F,x$ . From and extending upward from this labeled segment, draw a shaded rectangular bar.

Mathematical relationship

Signed area between  $F$ -sub- $x$ - $t$  plot and  $t$  axis =  $J$ -sub- $F,x$