

Title

Newton's 3rd Law (N3L)

Ingredients

Sketch



At/Through

t

Owner

System 1

System 2

Quantity

Force

Force

Variable

$\vec{F}_{2 \rightarrow 1}$

$\vec{F}_{1 \rightarrow 2}$

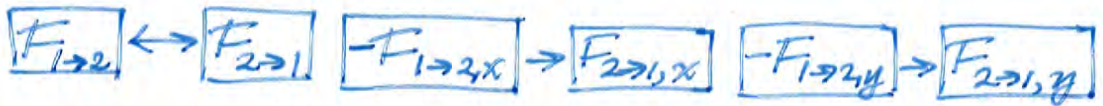
Giver

System 2

System 1

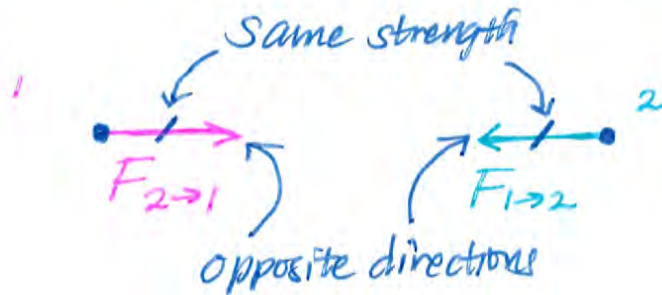
Recipe

Diagram the relationship



Graphically present quantities

Two separate force diagrams for two systems



Mathematical relationship

$\vec{F}_{2 \rightarrow 1} = -\vec{F}_{1 \rightarrow 2}$   $F_{2 \rightarrow 1, x} = -F_{1 \rightarrow 2, x}$   $F_{2 \rightarrow 1, y} = -F_{1 \rightarrow 2, y}$

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Title Newton's 3<sup>rd</sup> Law, abbreviated N3L

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: Large example sphere at left, surrounded by dashed bubble, labeled 1; Small example sphere at right, surrounded by dash-dot bubble, labeled 2

Remaining rows of Ingredients section are used for a flowchart illustrating the following: At time  $t$ , Owner System 1 exists and is receiving Quantity Force denoted by Variable  $F$ -vector-sub-2-on-1 given by Giver System 2. At time  $t$ , Owner System 2 exists and is receiving Quantity Force denoted by Variable  $F$ -vector-sub-1-on-2 given by Giver System 1.

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

$F$ -sub-1-on-2 and  $F$ -sub-2-on-1 are connected by a left-right double-headed arrow showing that each quantity can be thought of as a contributor to the other.

An arrow shows that negative  $F$ -sub-1-on-2, $x$  contributes to  $F$ -sub-2-on-1, $x$ .

An arrow shows that negative  $F$ -sub-1-on-2, $y$  contributes to  $F$ -sub-2-on-1, $y$ .

Graphically present quantities

Title: Two separate force diagrams for two systems

Dot at left, labeled 1, represents system 1.

Force arrow originates from dot 1, points toward right, and is labeled  $F$ -sub-2-on-1.

Dot at right, labeled 2, represents system 2.

Force arrow originates from dot 2, points toward left, and is labeled  $F$ -sub-1-on-2.

Geometry congruence hash marks indicate the two force arrows have the same size.

The congruence hash marks are emphasized by a caption that reads, "same strength".

The opposite directions of the force arrows are emphasized by the caption that reads, "opposite directions" with arrows pointing from this caption to the tips of the force arrows.

Mathematical relationship

$F$ -vector-2-on-1 = negative  $F$ -vector-1-on-2

$F$ -sub-2-on-1, $x$  = negative  $F$ -sub-1-on-2, $x$

$F$ -sub-2-on-1, $y$  = negative  $F$ -sub-1-on-2, $y$