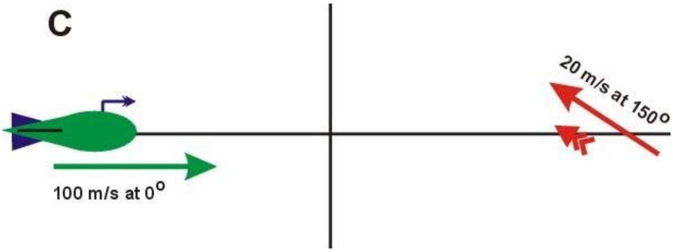
Relative-Motion Test for Unit Reliability



3. Puzzling the Reliability of *ρ* [*kgm/s*] as a Scientific Unit

Professor Du-Ane Du

www.Wacky1301SCI.com, *"Looking at serious science, sideways!"*

The third puzzle set that use relative motion to deduce which units are not reliable for scientific comparisons: (1) the reliability of *m*, *s*, *m/s*, (2) the unreliability of joules of kinetic energy and work-done, **(3) the reliability of *ρ*, [*kgm/s*] of impulse and momentum**. (1st month of a physics class.)

—By Du-Ane Du, Author of *Murdered Energy Mysteries*, (Amazon, Kindle, ebook 2018, paperback 2021).

In the mid 1600's Rene Descartes proposed that motion/momentum cannot be created or destroyed. In *Murdered Energy Mysteries*, the Space-Sci Sherlocks clarify Descartes basic premise as:

Cartesian #1 general conservation fact of motion/momentum [Descartes] (Chapter 101)**:** The total amount of motion/momentum in the universe never changes, therefore Object A cannot speed up unless a second object slows down, likewise Object B cannot slow down unless one or more other objects speeds up.

Cartesian #2 clarified conservation fact of r-s-t momentum [Descartes] (Chapter 101)**:** Radian/speed/trapped momentum can change forms (radian, speed, or trapped), r-s-t momentum can change natures (linear, multidirectional, or omnidirectional), and r-s-t momentum can be transferred from one object to another, but the total amount of r-s-t momentum in the universe never changes.

Symbols

$im\Delta\rho$ – impulse

10 ρ = 10 kgm/s

10 ρ = 10 N*s

5 ρ/s = 5 N

Before the law of conservation for momentum can be considered completely valid, the units *kgm/s* or ρ of momentum must pass the parallax/relative-motion test for unit reliability. (See Relativity Puzzle #1, “Puzzling the Reliability of *m*, *s*, and *m/s*”, www.Wacky1301SCI.com)

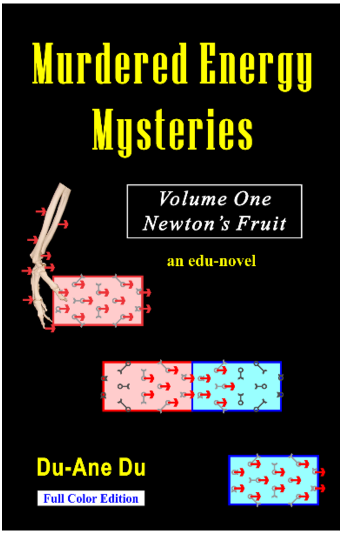
Note, for convenience, 1 ρ of momentum or impulse is equivalent to 1 kilogram moving at a speed of 1 m/s:

$$1\,\rho \;=\; 1\,kgm/s$$

Parallax/Relative-Motion
Test of Momentum Reliability

Our exploration of momentum-gain begins with two astronauts named Stacy Stationary and Ned Nearing. Stacy is standing on a motionless asteroid located deep in space. Ned will approach Stacy's asteroid at a variety of velocities. Stacy Stationary will place C-11 rocket engines into a variety of toy rockets, and she will launch the rockets at a variety of angles. The challenge for us will be to calculate the rocket's momentum-gain as measured from the perspective of Ned's Doppler laser.

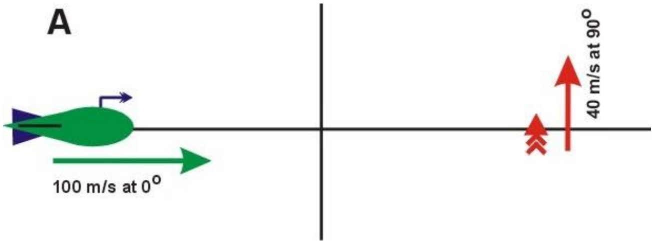
According to the manufacturer, the C-11 engine has an impulse rating of 10 ρ, or 10 kgm/s, which means each rocket should always gain 10 ρ of momentum for each engine burned. According to the rules of the parallax/relative-motion test, Ned's calculation of the impulse provided by the engine must never exceed the manufacturer's rating of $\pm 10\ \rho$. If the value is ever higher, then momentum is



being created, and the unit of *kgm/s* or *ρ* is invalid for scientific use.

It is important to understand that these puzzles are an indirect proof. *According to the rules of indirect proofs, if Ned has one single result outside the parallax range, then the conservation facts for r-s-t momentum and impulse is completely false.* Moreover, when the rocket is launched at 0 degrees and 180 degrees, the full width of the range must always be 10 kgm/s. If the range ever grows or shrinks, then the *kgm/s* and *ρ* units for impulse and momentum are unreliable and the proposed conservation facts for r-s-t momentum are false.

Scenario 1A: Ned Nearing's Doppler laser beam will serve as the X-axis of our reference graph. Ned is gliding toward Stacy Stationary's asteroid at a velocity of 100 m/s at 0°. Ned's Doppler laser is pointed so that Stacy is slightly "south" of his laser-beam. Stacy places a C-11 engine in a rocket and aims it at an angle of 90°. Stacy radios Ned and tells him the rocket has a mass of 0.25 kg. As Stacy launches the rocket, what will Ned record as the impulse/momentum-gain caused by the toy rocket's engine?



To solve the puzzle, we first note that Ned Nearing is approaching Stacy Stationary’s asteroid at a velocity of 100 m/s, which means Ned perceives Stacy’s toy rocket as having a starting velocity of –100 m/s. In other words, Ned thinks Stacy and the toy rocket are approaching him. (Note that because Stace is on a stationary asteroid, the starting velocity of the toy rocket before each launch will always be –100 m/s).

Next, we use the Newton’s-first-law equation to calculate the final velocity of the toy rocket, from Stacy Stationary’s perspective:

$$mv_{final} = mv_{initial} + im\Delta\rho$$

$$(0.25\ kg)v_{final} = (0.25\ kg)\left(0\frac{m}{s}\right) + 10\ kg\frac{m}{s}$$

$$(0.25\ kg)v_{final} = 10\ kg\frac{m}{s}$$

launch velocity = 40 m/s at 90 degrees

Ned’s Doppler laser can only measure the X-component of the toy rocket’s motion. We can use the cosine equation to calculate the X-component of the rocket’s total velocity:

$$X\text{-}component = M_{Resultant} \times cos(\emptyset)$$

$$X\text{-}component = (40.0\frac{m}{s})cos(90°)$$

X-component = 0 m/s, rightward

Ned is traveling +100 m/s at 0°, so his Doppler laser will record the rocket’s velocity as:

rocket's net velocity = (Rocket-X) – (Ned Nearing)

$rocket\ velocity = (0\frac{m}{s}) - (+100\frac{m}{s})$

rocket velocity = –100 m/s, or 100 m/s moving closer

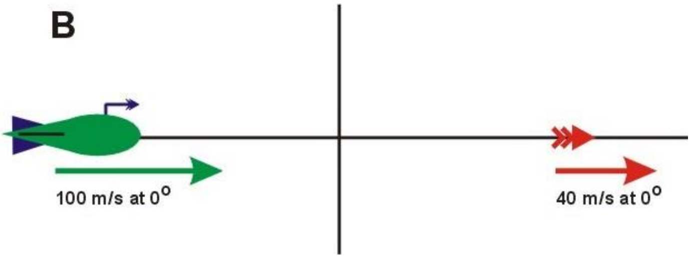
Finally, we can calculate the impulse/momentum-gain produced by the toy engine as seen from Ned's perspective:

$im\Delta\rho = mv_{final} - mv_{initial}$

$im\Delta\rho = (0.25\ kg)(-100\ \frac{m}{s}) - (0.25\ kg)\left(-100\ \frac{m}{s}\right)$

imΔρ = 0 ρ, or 0 kgm/s

Scenario 1B: Ned continues to approach at a speed of 100 m/s. Stacy Stationary rotates the launch pad so the next rocket is launched at an angle of 0° relative to the Ned's laser-beam.



Based on our earlier calculations, we know that Stacy's toy rocket will have a final velocity of 40 m/s at 0°. The rocket is flying rightward along the X-axis, therefore the X-component of the velocity will have a magnitude of 40 m/s.

Next, we calculate the final velocity as detected by Ned's Doppler laser:

$$\textit{rocket's net velocity} = \textit{(Rocket-X)} - \textit{(Ned Nearing)}$$

$$\textit{rocket velocity} = \left(+40\,\frac{m}{s}\right) - \left(+100\,\frac{m}{s}\right)$$

$$\textbf{\textit{rocket velocity}} = \boldsymbol{-60\ m/s}\textbf{\textit{, or 60 m/s moving closer}}$$

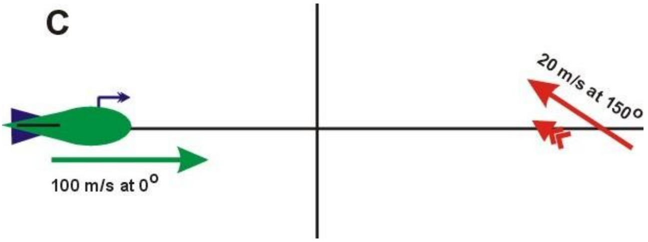
Notice that Ned perceives the rocket as moving closer, even though the rocket is moving rightward to our perspective. Now we can calculate the impulse/momentum-gain as seen from Ned's perspective:

$$im\Delta\rho = mv_{final} - mv_{initial}$$

$$im\Delta\rho = (0.25\ kg)\left(-60\ \frac{m}{s}\right) - (0.25\ kg)\left(-100\ \frac{m}{s}\right)$$

$$\boldsymbol{im\Delta\rho = 10\ \rho}\textbf{\textit{, or 10 kgm/s}}$$

Scenario 1C: Stacy Stationary rotates the next rocket so it launches at an angle of 150°.



As before, Ned's Doppler laser can only measure the X-component of the rocket's velocity. The rocket has a final forward velocity of 40 m/s at 150°, and the cosine equation will give us an X-component of:

$$\textit{X-component} = M_{Resultant} \times cos(\emptyset)$$

$$\textit{X-component} = \left(40.0\,\frac{m}{s}\right)cos(150°)$$

X-component = –34.64 m/s

Next, we calculate the toy rocket’s final velocity as detected by Ned’s Doppler laser:

rocket's net velocity = (Rocket-X) – (Ned Nearing)

$$rocket\ velocity = \left(-34.64\frac{m}{s}\right) - \left(+100\frac{m}{s}\right)$$

rocket velocity = –134.64 m/s, or 134.64 m/s moving closer

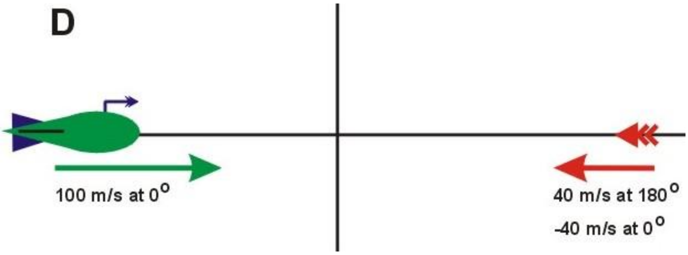
Finally, we calculate the impulse/momentum-gain as seen from Ned Nearing’s perspective:

$$im\Delta\rho = mv_{final} - mv_{initial}$$

$$im\Delta\rho = (0.25\ kg)\left(-134.64\ \frac{m}{s}\right) - (0.25\ kg)\left(-100\ \frac{m}{s}\right)$$

imΔρ = –8.66 ρ, or –8.66 kgm/s

Scenario 1D: Stacy Stationary rotates the launch pad so her next 0.25 kg rocket is launched at an angle of 180°.



Remember that a final velocity of 40 m/s at 180° is the same thing as –40 m/s at 0°. Once again, the toy rocket is flying along the X-axis. This means the X-component of the rocket’s velocity is –40 m/s.

Our calculations for the toy rocket's final velocity as detected by Ned's Doppler laser are:

rocket's net velocity = (Rocket-X) – (Ned Nearing)

$$rocket\ velocity = \left(-40\frac{m}{s}\right) - \left(+100\frac{m}{s}\right)$$

rocket velocity = –140 m/s, or 140 m/s moving closer

Now we can calculate the impulse/momentum-gain from Ned Nearing's perspective:

$$im\Delta\rho = mv_{final} - mv_{initial}$$

$$im\Delta\rho = (0.25\ kg)\left(-140\ \frac{m}{s}\right) - (0.25\ kg)\left(-100\ \frac{m}{s}\right)$$

imΔρ = –10 ρ, or –10 kgm/s

Comparison with Manufacturer's Ratings

The manufacturer of the C-11 rocket engine designed it to produce an impulse/momentum-gain of 10 *ρ*. This measurement is not a vector. How the engine is attached and which direction the engine is pointed will determine if the impulse is forward (+10 *ρ*), backward (–10 *ρ*), or somewhere in between.

With that in mind, we now need to compile a data table that compares the manufacturer's original data to the impulse/momentum-gain data compiled from Ned's perspective:

Ned Nearing's Impulse Calculations vs Manufacturer's Impulse Ratings		**E**
Manufacturer's Original Ratings	**Ned Nearing is moving at 100 m/s, 0°**	
The rating of 10 ρ of impulse can be either positive or negative depending on direction of the launch.	**Impulse calculated by Ned**	
	Scenario 1A	**0 ρ**
	Scenario 1B	**+10 ρ**
	Scenario 1C	**−8.66 ρ**
	Scenario 1D	**−10 ρ**
Parallax Range	**Parallax Range**	
±10 **ρ**	**±10 ρ**	

Notice that even though Ned is moving, he has concluded that the C-11 engine produces a maximum impulse/ momentum-gain of 10 ρ. This conclusion matches the manufacturer's rating for the C-11 rocket engine.

While one test cannot provide absolute proof, this single example does suggest that the conservation facts for r-s-t momentum and impulse are reliable with respect to relative motion. Now we need to repeat the test using a wider range of relative velocities, and using different rockets and engines.

PUZZLES FOR FURTHER RESEARCH AND UNDERSTANDING

3) **Scenario 3:** The D-12 rocket engine is designed to produce 20 *ρ*, or 20 kg/s, of impulse/momentum-gain.
   a. If Stacy Stationary places a D-12 engine in a 0.25 kg rocket, what will the rocket's final velocity be after the engine burns?
   b. Ned Nearing is approaching Stacy's asteroid at a velocity of 500 m/s at 0°, and Stacy launches the rocket at an angle of 0°. What is Ned's calculation of the impulse produced by the engine?
   c. Ned is approaching Stacy's asteroid at a velocity of 500 m/s at 0°, and Stacy launches the rocket at an angle of 70°. What is Ned's calculation of the impulse produced by the engine?
   d. Ned is approaching Stacy's asteroid at a velocity of 500 m/s at 0°, and Stacy launches the rocket at an angle of 180°. What is Ned's calculation of the impulse/momentum-gain produced by the engine?
4) **Scenario 4:** The D-12 rocket engine is designed to produce 20 *ρ*, or 20 kg/s, of impulse/momentum-gain.
   a. If Stacy Stationary places a D-12 engine in a 0.50 kg rocket, what will the rocket's final velocity be after the engine burns?

- b. Ned Nearing is approaching Stacy’s asteroid at a velocity of 1,000 m/s at 0°, and Stacy launches the rocket at an angle of 0°. What is Ned’s calculation of the impulse produced by the engine?
- c. Ned is approaching Stacy’s asteroid at a velocity of 1,000 m/s at 0°, and Stacy launches the rocket at an angle of 120°. What is Ned’s calculation of the impulse produced by the engine?
- d. Ned is approaching Stacy’s asteroid at a velocity of 1,000 m/s at 0°, and Stacy launches the rocket at an angle of 180°. What is Ned’s calculation of the impulse/ momentum-gain produced by the engine?

5) Develop a comparison table for the manufacturer’s rating of a D-12 engine, and Ned’s calculations during Scenario 3b, 3c, 3d, and during Scenario 4b, 4c, and 4d.

Scenarios 3 & 4. Ned Nearing's Impulse Calculations vs Manufacturer's Impulse Ratings				**F**
Manufacturer's Original Impulse Rating	**Ned Nearing moving at 500 m/s, 0°**		**Ned Nearing moving at 1,000 m/s, 0°**	
20 ρ	3B		4B	
	3C		4C	
	3D		4D	
Parallax Range	**Parallax Range**		**Parallax Range**	
±20 ρ				

6) The manufacturer rated the D-12 engine as able to consistently produce ±20 ρ, or 20 kg/s, of impulse/momentum-gain.
   a. Did Ned Nearing's calculations while traveling at 500 m/s match the manufacturer's rating?
   b. Did Ned's calculations while traveling at 1,000 m/s match the manufacturer's rating?
   c. **Does this suggest that ρ of momentum-gain is a reliable unit of measure for scientists to use on a regular basis?**
7) **Scenario 7:** The E-9 rocket engine is designed to produce 30 ρ , or 30 kg/s,of impulse/momentum-gain.

   a. If Stacy Stationary places an E-9 engine in a 0.25 kg rocket, what will the rocket’s final velocity be after the engine burns?
   b. Ned Nearing is approaching Stacy’s asteroid at a velocity of 5,000 m/s at 0°, and Stacy launches the rocket at an angle of 0°. What is Ned’s calculation of the impulse produced by the engine?
   c. Ned is approaching Stacy’s asteroid at a velocity of 5,000 m/s at 0°, and Stacy launches the rocket at an angle of 30°. What is Ned’s calculation of the impulse produced by the engine?
   d. Ned is approaching Stacy’s asteroid at a velocity of 5,000 m/s at 0°, and Stacy launches the rocket at an angle of 180°. What is Ned’s calculation of the impulse/momentum-gain produced by the engine?

8) **Scenario 8:** The E-9 rocket engine is designed to produce 30 ρ, or 30 kg/s, of impulse/momentum-gain.
   a. If Stacy Stationary places an E-9 engine in a 0.10 kg rocket, what will the rocket’s final velocity be after the engine burns?
   b. Ned Nearing is approaching Stacy’s asteroid at a velocity of 10,000 m/s at 0°, and Stacy launches the rocket at an angle of 0°. What is Ned’s calculation of the impulse produced by the engine?
   c. Ned is approaching Stacy’s asteroid at a velocity of 10,000 m/s at 0°, and Stacy launches the rocket at an

angle of 160°. What is Ned's calculation of the impulse produced by the engine?

d. Ned is approaching Stacy's asteroid at a velocity of 10,000 m/s at 0°, and Stacy launches the rocket at an angle of 180°. What is Ned's calculation of the impulse/momentum-gain produced by the engine?

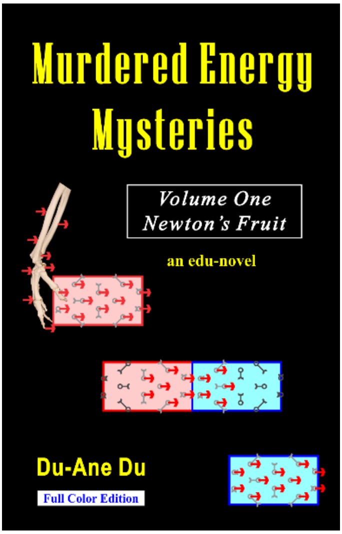
9) Develop a comparison table for the manufacturer's rating of an E-9 engine, and Ned's calculations during Scenario 7b, 7c, 7d, and during Scenario 8b, 8c, and 8d.

<table>
<tr><th colspan="4">Scenarios 7 & 8.
Ned Nearing's Impulse Calculations vs Manufacturer's Impulse Ratings</th><th>G</th></tr>
<tr><th>Manufacturer's Original Impulse Rating</th><th colspan="2">Ned Nearing moving at 5,000 m/s, 0°</th><th colspan="2">Ned Nearing moving at 10,000 m/s, 0°</th></tr>
<tr><td rowspan="3">30 $\boldsymbol{\rho}$</td><td>7B</td><td></td><td>8B</td><td></td></tr>
<tr><td>7C</td><td></td><td>8C</td><td></td></tr>
<tr><td>7D</td><td></td><td>8D</td><td></td></tr>
<tr><th>Parallax Range</th><th colspan="2">Parallax Range</th><th colspan="2">Parallax Range</th></tr>
<tr><td>±30 $\boldsymbol{\rho}$</td><td colspan="2"></td><td colspan="2"></td></tr>
</table>

10) The manufacturer rated the E-9 engine as able to consistently produce ±30 ρ, or 20 kg/s, of impulse/momentum-gain.

a. Did Ned Nearing's calculations while traveling at 5,000 m/s match the manufacturer's rating?
b. Did Ned's calculations while traveling at 10,000 m/s match the manufacturer's rating?
c. **Does this suggest that *ρ* of momentum-gain is a reliable unit of measure for scientists to use on a regular basis?**

* * *



Examine or purchase at Amazon.com

Murdered Energy Mysteries seeks to increase understanding of the various forms of momentum and momentum transfer, as well as the various forms of energy and energy transfer. The lack of understanding on the part of the scientific community is substantial, and more research needs to be done.

—Du-Ane Du, author of the edu-novel *Murdered Energy Mysteries* (Amazon, Kindle, e-book 2018, paperback 2021.)

More information, visit www.Wacky1301SCI.com