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This program solves glancing (two-dimensional) collision problems involving 2 smooth, non-rotating objects. Elastic, inelastic, and completely inelastic collisions are treated. The simplest are those in which the *x*-axis is along the line of impact since a coefficient of restitution (*r*) can be defined, and if known, all required equations are linear. For cases in which *r* is either unknown or cannot be defined, energy equations must be used. Because these are quadratic, 2 'possible' solutions result in many cases. Usually, on closer inspection, one solution would require the objects to pass through each other. So that solution is mathematically possible but physically impossible.

The required input varies depending on collision type, but may include masses, initial or final velocities, $r$ ( coefficient of restitution), $KE$ (final kinetic energy), $\Delta KE$ (change in kinetic energy), or $\beta$ (% change in kinetic energy). Results can include either initial or final values depending on input. Any unknowns among $KE$, $KEo$, $\Delta KE$, $\beta$, and *r* (when possible) are included in results. Momentum and energy equations can displayed as computed, if desired. This feature is presently disabled to speed up operation. To display the equations, remove all @ characters in the program. Changes in the masses of the objects are permitted so that some two body nuclear reactions can be handled.

It can also handle head-on (1 dimensional) collisions as well as "explosions", in which one object breaks into two pieces. But for these one-dimensional cases, it's easier to download and use Collisun().

I've only found one situation in which no correct solution results. The Solve function can't handle the case in which the magnitudes of two velocities are known and both angles must be found. However in some cases, if both the magnitudes and directions of the two velocities are unknown, the program avoids the problem by first finding the *x* and *y* components of the velocities, then using them to find the magnitudes and directions. In any case, the calculations require some time, so be patient.

Although any system of units can be used, all quantities must be expressed in the same system when both momentum and energy are involved.

All solutions are copied to the home screen so they can be more easily used in further calculations

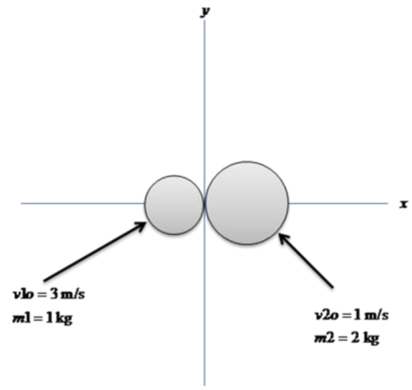
Since the data input is done in dialog boxes, I recommend that you download and install autoaoff(), which turns off the auto alpha lock in dialog boxes.

Place Collis2d(), Mysolv2(),Pieces(),Getnames(), Replace(), and Copyto_h() in the same folder, then run Collis2d().

Several examples are given below.

Examples:

1. Two smooth disks collide with initial velocities as shown. The $x$-axis shown is along the line of impact, so the coefficient of restitution, $r = 0.75$ in this case, can be used. Determine the velocity of each object just after the collision.




Run Collis2d().

No They do not stick together.

Yes $x$-axis is along line of centers (line of impact).

$m1 = 1$

$v1o = 3$

$\theta 1o = 30$

3 values known, 4 needed in next 3 boxes

$m2 = 2$

$v2o = 1$

$\theta 2o = 225$

6 values known, 1 needed in next 2 boxes

No The masses do not change

$v1 = v1$

$\theta 1 = \theta 1$

$v2 = v2$

$\theta 2 = \theta 2$

No entries

$r = .75$

$\beta = \beta$

$KE = ke$

$\Delta KE = \Delta ke$

Solution :

$KEo = 5.5$

$KE = 3.9069$

$\Delta KE = -1.5931$

$\beta = -28.966$

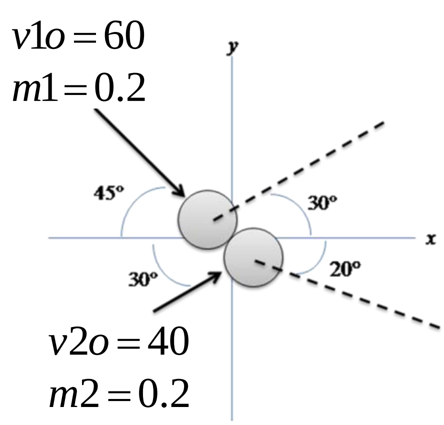
$v1 = 1.9577$

$\theta 1 = 129.98$

$v2 = 1.4109$

$\theta 2 = -30.078$

2. Two hockey pucks, each of mass 200 grams, collide and are deflected along the dashed paths. Determine their speeds just after impact.




Run Collis2d().

No They do not stick together.

No $x$-axis is not along line of centers (line of impact).

$m1 = .2$

$v1o = 60$

$\theta 1o = -45°$

3 values known, 5 needed in next 3 boxes

$m2 = .2$

$v2o = 40$

$\theta 2o = 30$

6values known, 2 needed in next 2 boxes

No The masses do not change.

$v1 = v1$

$\theta 1 = 30$

$v2 = v2$

$\theta 2 = -20$

8 values known, 0 needed in next box

$\beta = \beta$

$KE = ke$ No entries

$\Delta KE = \Delta ke$

Solution :

$KEo = 520$

$KE = 577.14$

$\Delta KE = 57.136$

$\beta = 10.988$

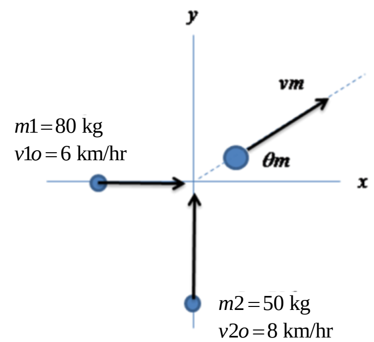
$v1 = 6.8987$

$v2 = 75.656$

An unrealistic problem.

Where did that extra energy come from?

3. Completely inelastic collision.
Two skaters collide and embrace, then move together as one object after the collision. Find their velocity just after the collision.




Since only momentum, and not kinetic energy, will be involved in the solution, the mass units will cancel out, and the velocity will be in km/hr. If energy is involved, convert to consistent units, m/s.

Run Collis2d().
Yes They stick together.

$m1 = 80$

$v1o = 6$

$\theta 1o = 0$

3 values known, 3 needed in next 3 boxes

$m2 = 50$

$v2o = 8$

$\theta 2o = 90$

6values known, 0 needed in next 2 boxes

$vm = vm$

$\theta m = \theta m$ No entries

6values known, 0 needed in next box

$\beta = \beta$

$KE = ke$ No entries

$\Delta KE = \Delta ke$

Solution :

$KEo = 3040$

$KE = 1501.5$

$\Delta KE = -1538.5$

$\beta = -50.607$

$vm = 4.8063$

$\theta m = 39.806$

4. Sometimes a partial solution can be found even when not enough information is given to completely solve the problem.

Two balls, 1 and 2, having different but unknown masses, collide. Ball 1 is initially at rest while ball 2 has speed $v2o$. After collision ball 2 has a speed ½ ($v2o$) and moves at right angles to its original direction. Find the direction in which ball 1 moves after the collision.
Run Collis2d().
No They do not stick together.
No $x$-axis is not along line of centers (line of impact).

$m1 = m1$

$v1o = 0$ When the magnitude of a velocity is 0, enter 0 for the

$\theta 1o = 0$ direction also, so that the number of needed values is correct.

2 values known, 6 needed in next 3 boxes

$m2 = m2$

$v2o = v2o$

$\theta 2o = 0$

3 values known, 5 needed in next 2 boxes

No The masses do not change.

$v1 = v1$

$\theta 1 = \theta 1$

$v2 = v2o / 2$

$\theta 2 = 90$

5 values known, 3 needed in next box

$\beta = \beta$

$KE = ke$ No entries

$\Delta KE = \Delta ke$

Too many unknowns: $m1, m2, v1x, v1y, v2o$

Only 2 equations, need to delete 3 unknowns.

Delete $m1, m2, v2o$.

The solution will be in terms of $m1, m2, v2o$.

Solution:

$KEo = .5 \cdot m2 \cdot v2o^2$

$$KE = \frac{.625 \cdot m2^2 \cdot v2o^2}{m1} + .125 \cdot m2 \cdot v2o^2$$

$$\Delta KE = \frac{.625 \cdot m2^2 \cdot v2o^2}{m1} - .375 \cdot m2 \cdot v2o^2$$

$$\beta = \frac{-75 \cdot (m1 - 1.6667 \cdot m2)}{m1}$$

$$v1 = 1.118 \cdot \left| \frac{m2 \cdot v2o}{m1} \right|$$

$\theta 1 = 63.435 - 90 \cdot \text{sign}(m1 \cdot m2 \cdot v2o)$

Since $m1, m2,$ and $v2o$ are all positive

$\theta 1 = 63.435 - 90 = -26.565$

None of the other quantities can be determined.

5. A gas molecule collides elastically with an identical molecule, which is initially at rest. After the collision, the first molecule moves 260 m/s at an angle of 30° to its initial direction. Find the final velocity of the second molecule and the initial speed of the first.

Run Collis2d().

No They do not stick together.

No *x*-axis is not along line of centers (line of impact).

$m1 = m$

$v1o = v1o$

$\theta 1o = 0$

2 values known, 6 needed in next 3 boxes

$m2 = m$

$v2o = 0$

$\theta 2o = 0$

5 values known, 3 needed in next 2 boxes

No The masses do not change

$v1 = 260$

$\theta 1 = 30$

$v2 = v2$

$\theta 2 = \theta 2$

7 values known, 1 needed in next box

$\beta = \beta$

$KE = ke$

$\Delta KE = 0$

Too many unknowns: $m, v1o, v2x, v2y$

Only 3 equations, need to delete 1 unknown.

Delete $m$. The solution will be in terms of $m$.

Solution:

$KEo = 45067 \cdot m$

$KE = 45067 \cdot m$

$\beta = -2.54 \times 10^{-10}$

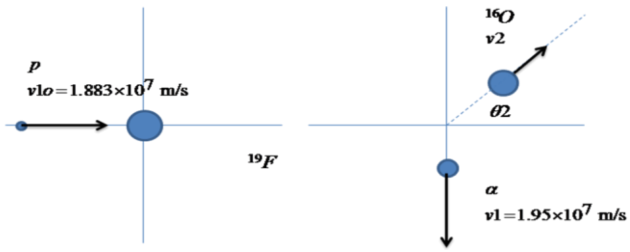
$v1o = 300.22$

$v2 = 150.11$

$\theta 2 = -60$

6. The program can be used in some cases of two body nuclear interactions. Speeds must be low enough so that the non-relativistic expression for kinetic energy $(\frac{1}{2}mv^2)$ can be used.

In the reaction ${}^{19}F + p \rightarrow {}^{16}O + \alpha$, a proton moving at $1.883 \times 10^7$ m/s collides with a fluorine nucleus, at rest. The $\alpha$ particle moves at right angles to the path of the incident proton, with a speed of $1.95 \times 10^7$ m/s. Find the velocity of the oxygen nucleus and the energy release in the interaction.




The masses of the particles are:

$m1\ (p) = 1.6766 \times 10^{-27}$ kg

$m2\ ({}^{19}F) = 3.154 \times 10^{-26}$ kg

$m3\ (\alpha) = 6.64 \times 10^{-27}$ kg

$m4\ ({}^{16}O) = 2.656 \times 10^{-26}$ kg

Run Collis2d().

No They do not stick together.

No *x*-axis is not along line of centers (line of impact).

$m1 = 1.6766 \times 10^{-27}$ kg

$v1o = 1.883 \times 10^7$

$\theta 1o = 0$

3 values known, 5 needed in next 3 boxes

$m2 = 3.154 \times 10^{-26}$

$v2o = 0$

$\theta 2o = 0$

6 values known, 2 more needed

Yes The masses do change.

$m3 = 6.64 \times 10^{-27}$

$m4 = 2.656 \times 10^{-26}$

$v1 = 1.95 \times 10^7$

$\theta 1 = -90$

$v2 = v2$

$\theta 2 = \theta 2$

8 values known, 0 needed in next box

$\beta = \beta$

$KE = ke$ No entries

$\Delta KE = \Delta ke$

Solution :

$KEo = 2.9724 \times 10^{-13}$

$KE = 1.5968 \times 10^{-12}$

$\Delta KE = 1.2996 \times 10^{-12}$

$\beta = 437.22$

$v2 = 5.0178 \times 10^{6}$

$\theta 2 = 76.297$

$\Delta KE = 1.2996 \times 10^{-12}\ \text{J} = 8.12\ \text{MeV}$