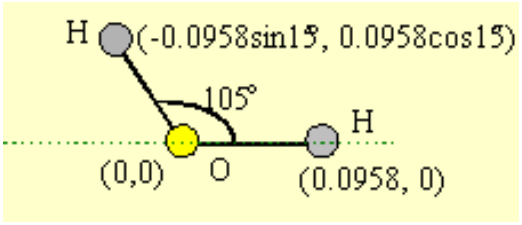
a) The distance between the oxygen molecule and each of the hydrogen atoms in a water (H2O) molecule is 0.96 Å and the angle between the two oxygen-hydrogen bonds is 105°. Treating the atoms as particles, find the centre of mass of the system.

Solution:

a)

The first step is to choose a coordinate system, such as the one in the diagram, and locate each particle. The chosen origin is the centre of the box.



Atom	Mass (H)	x_i	y_i	m_ix_i	m_iy_i
H	1	-0.96sin15	0.96cos15	-0.248466	0.927289
O	16	0	0	0	0
H	1	0.96	0	0.96	0
Totals:	18			0.711534	0.927289

The coordinates of the centre of mass are given by

$$x_{cm} = \frac{\sum m_i x_i}{M_{total}} = \frac{0.711534}{18} = 0.0395297 = 0.0395 \text{ Å}$$

And

$$y_{cm} = \frac{\sum m_i y_i}{M_{total}} = \frac{0.927289}{18} = 0.051516 = 0.0515 \text{ Å}$$

Answers will vary based on the choice of coordinate system.

b) A stationary ball, with a mass of 0.2 kg, is struck by an identical ball moving at 4.0 m/s. After the collision, the second ball moves 60° to the left of its original direction. The stationary ball moves 30° to the right of the moving ball's original direction. What is the velocity of each ball after the collision?

Solution:

u = 4.0 m/s is initial speed of second ball

Let the velocity of the stationary ball and moving ball is v_1 and v_2 m/s respectively after the collision

By the law of momentum conservation in X-Y plane:

$$mv_1\cos30° + mv_2\cos60° = mu$$

$$v_1\cos30° + v_2\cos60° = u \quad (1)$$

$$mv_1\sin30° = mv_2\sin60° \quad (2)$$

From (2):

$$0.5v_1 = 0.866v_2$$

$v_1 = 1.732v_2$ by putting this value in (1):

$$1.732v_2 \times 0.866 + v_2 \times 0.5 = 4.0$$

$$v_2 = 4.0/(1.732 \times 0.866 + 0.5) = 2.0$$

$$v_2 = 2.0 \text{ m/s}$$

Hence $v_1 = 3.464$ m/s

Answer. a) The centre of mass is located at (0.0395 Å, 0.0515 Å).

b) final speed of initially stationary ball 3.46 m/s,

final speed of initially moving ball 2.0 m/s