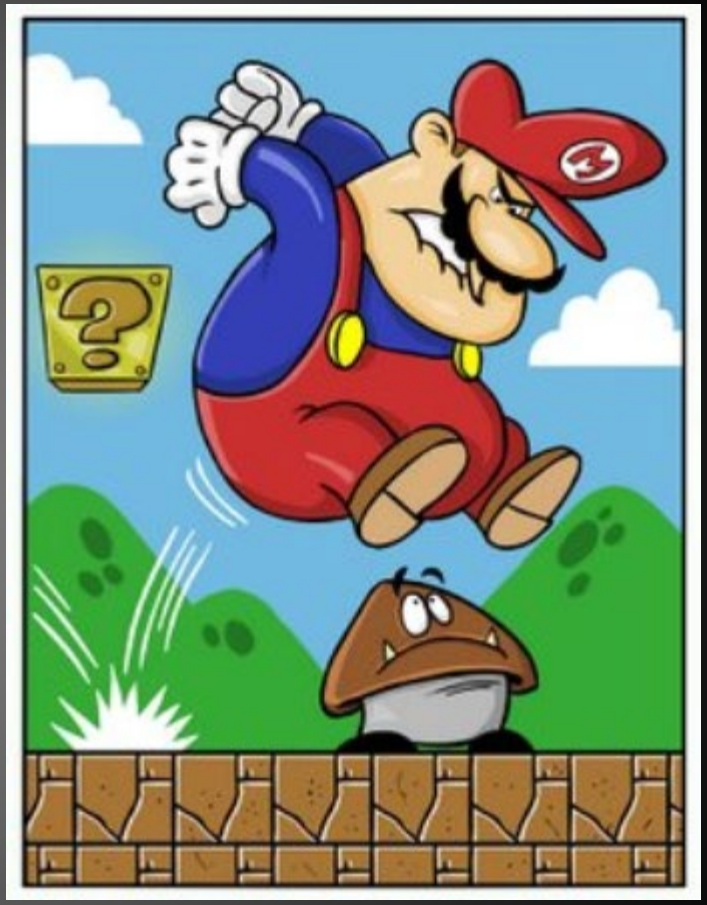
Collisions in 2D



Objectives

- explain, quantitatively, that momentum is conserved in one and two-dimensional interactions in an isolated system

Diploma Question Alert!

1. Which of the following quantities are scalar quantities?

   A. Kinetic energy and potential energy
   B. Kinetic energy and momentum
   C. Potential energy and force
   D. Momentum and force

Diploma Question Alert!

Use the following information to answer the first question.

The two objects shown above collide head-on. The velocity of the 9.5 kg object after collision is 5.4 m/s to the left.

1. The velocity of the 2.4 kg object after collision is

A. 15 m/s to the right
B. 8.7 m/s to the left
C. 8.0 m/s to the right
D. 6.2 m/s to the left

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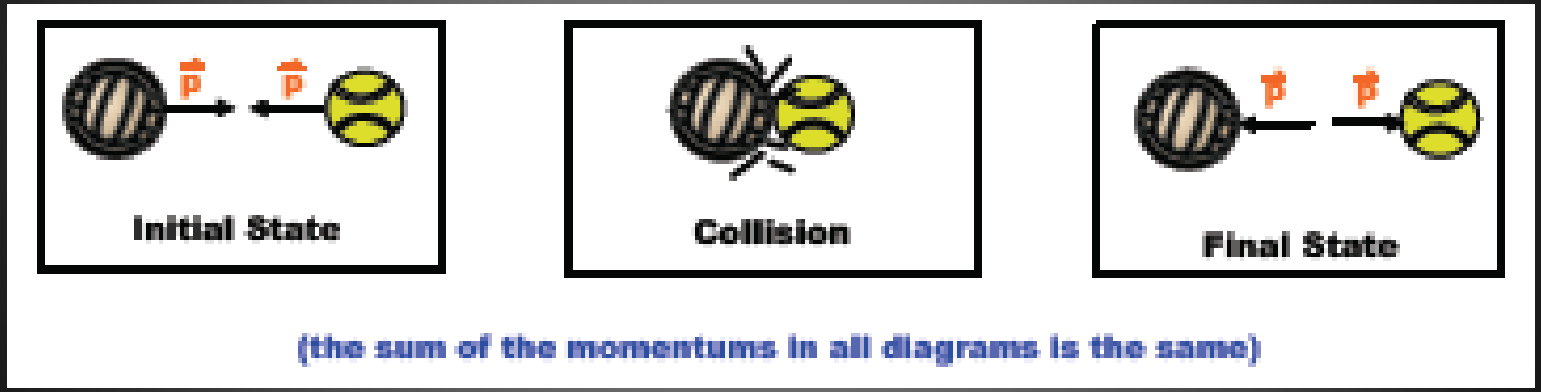
Numerical Response

1. A 1 575 kg car, initially travelling at 10.0 m/s, collides with a stationary 2 250 kg car. The bumpers of the two cars become locked together. The speed of the combined cars immediately after impact is _____m/s.

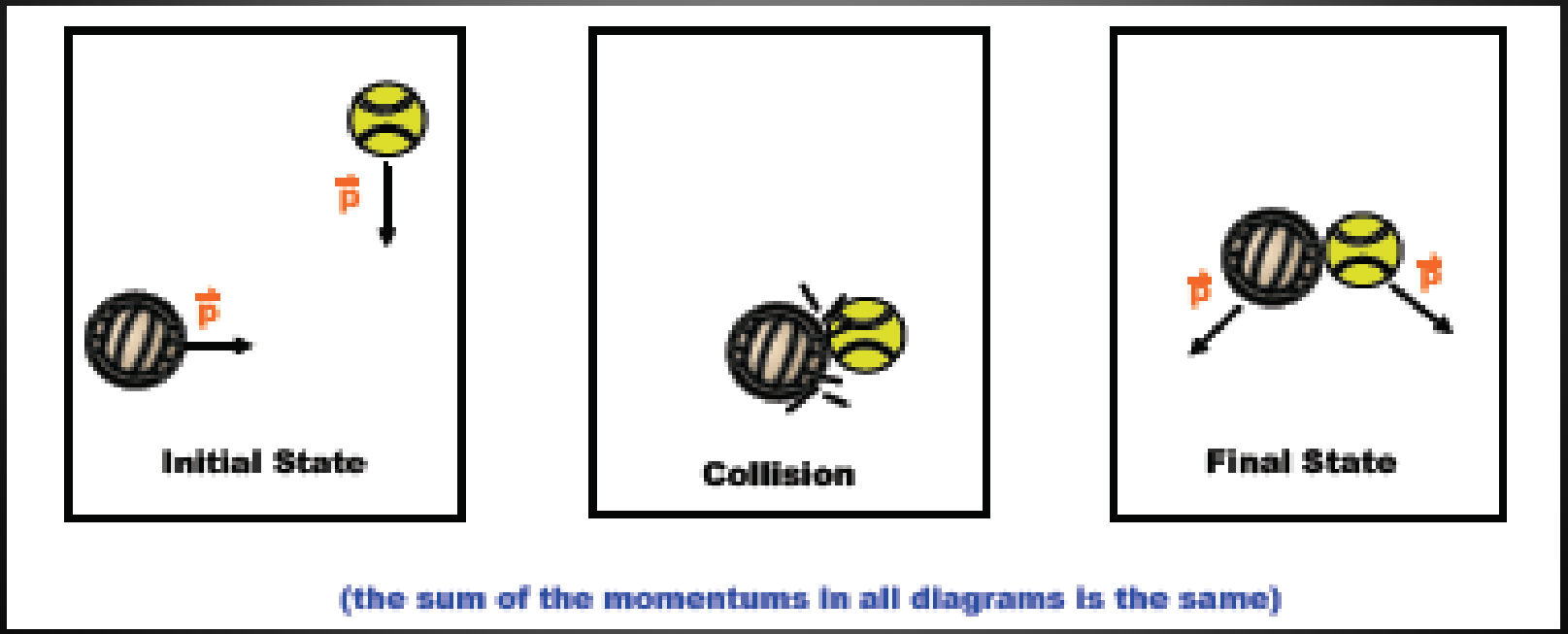
(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

Nonlinear Conservation of Momentum

- Just as momentum is conserved in one dimension,



- it is also conserved in other, nonlinear directions.



- **In situations where objects are moving in two dimensions (i.e. the x and y direction), we need to break the momentum vectors into components.**
- **The components in the x direction will be conserved and the components in the y direction will be conserved.**

Example/Steps

- **ex) A 4.0 kg cat is traveling South at 2.8 m/s when it collides with a 6.0 kg bat traveling East at 3.0 m/s. The objects stick together upon collision. What is the velocity of the cat-bat system?**

- **Step 1: Draw a diagram.**

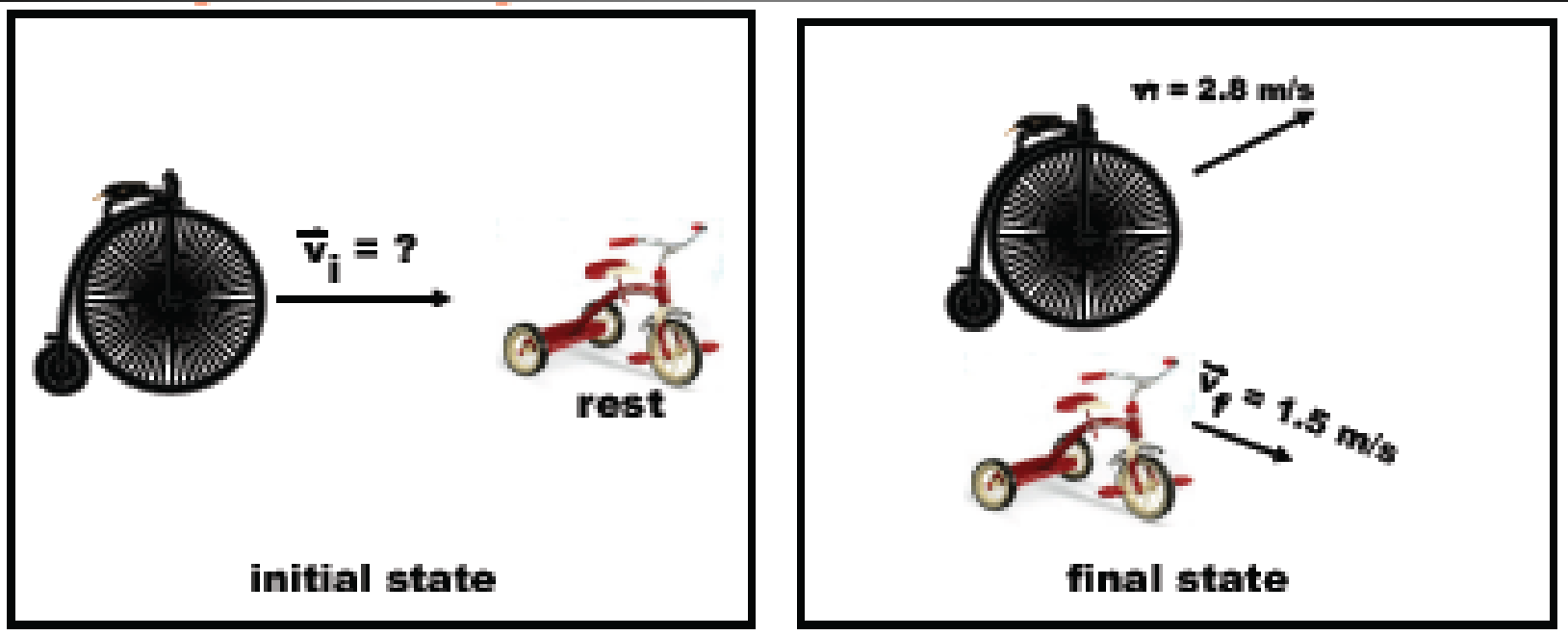
- **Step 2: Write separate conservation statements for x and y directions.**
- **x-direction** **y-direction**

- **Step 3: Find final momentum in x and y direction**

- **Step 4: Find the resultant momentum using vectors. Solve for velocity.**

Let's take a look at a "glancing collision".

- ex) A 4.0 kg bicycle is moving East at an unknown velocity when it hits a stationary 6.1 kg tricycle. After collision, the bicycle moves at 2.8 m/s 32° N of E and the tricycle moves at 1.5 m/s at 41° S of E. What is the initial velocity of the bicycle?



- **Step 1: Draw a diagram.**

- **Step 2: Break vectors into components.**

- **Step 3: Write conservation statements for the x and y.**

- **Step 4: Solve for the unknown variable.**

- **Step 5: Using the found momentum, determine the missing momentum and solve for velocity.**

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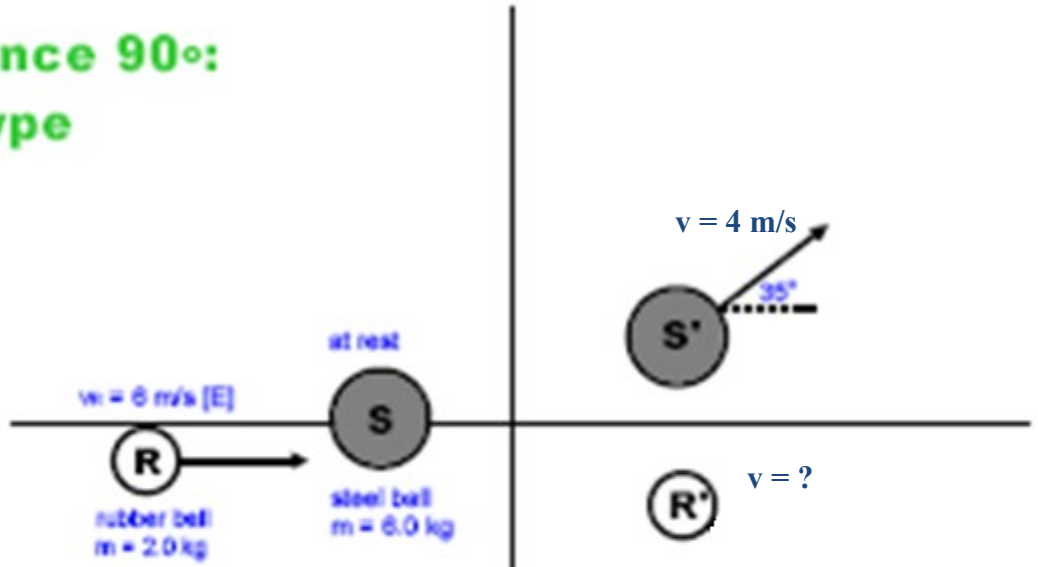
3. A 115 g arrow travelling east at 20 m/s imbeds itself in a 57 g tennis ball moving north at 42 m/s. The direction of the ball-and-arrow combination after impact is

   A. 46° N of E
   B. 46° E of N
   C. 25° E of N
   D. 25° N of E

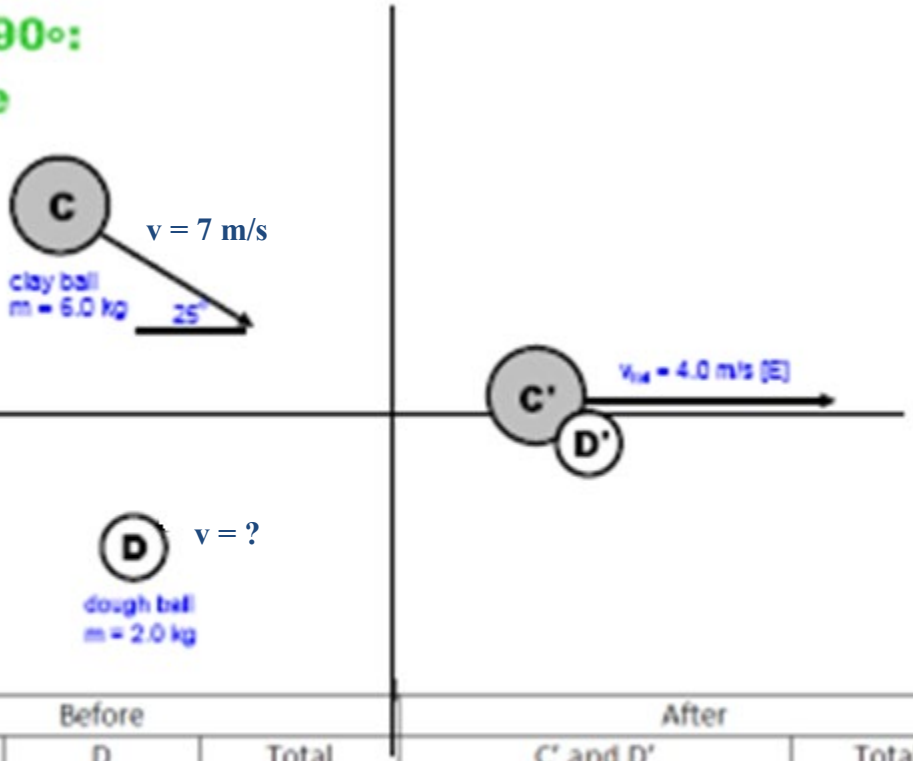
Example

Hit and Bounce 90◦:
1-triangle type



	Before			After		
	R	S	Total	R'	S'	Total'
p_x						
p_y						

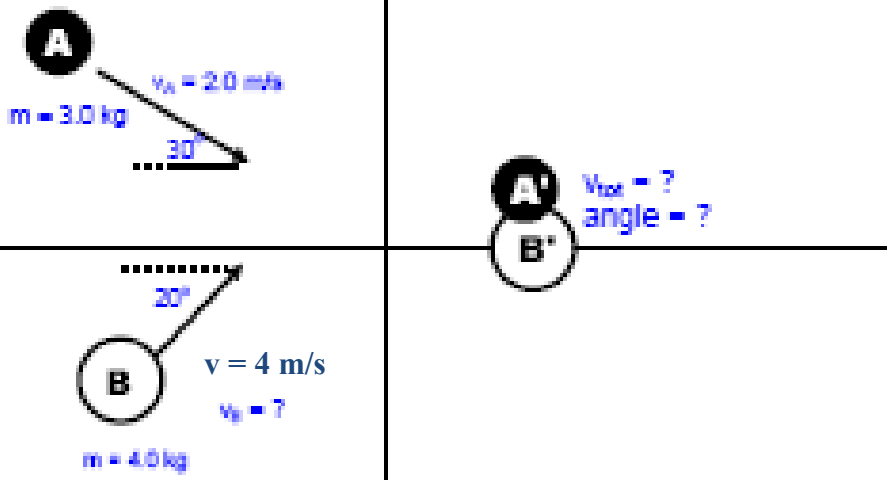
Hit and Stick 90◦:
1-triangle type



	Before			After	
	C	D	Total	C' and D'	Total'
p_x					
p_y					

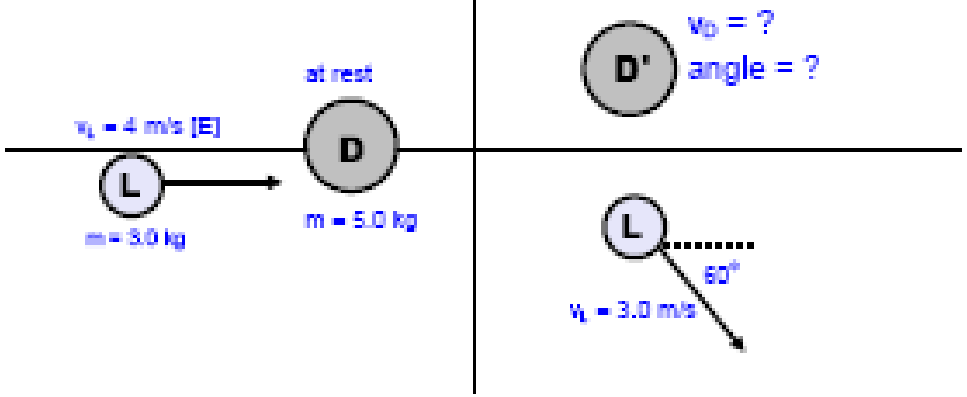
Hit and Stick (putty balls)

3-triangle type



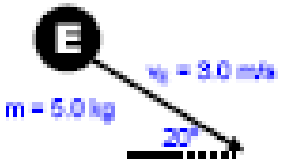
	Before			After	
	A	B	Total	A' and B'	Total'
p_x					
p_y					

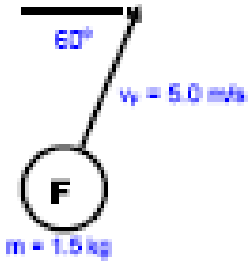
Hit and Bounce (rubber balls)
2-triangle type

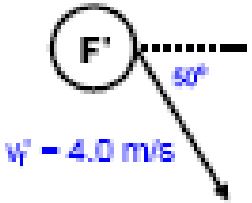


	Before			After		
	A	B	Total	A'	B'	Total'
p_x						
p_y						

Hit and Bounce (rubber balls)
4-triangle type

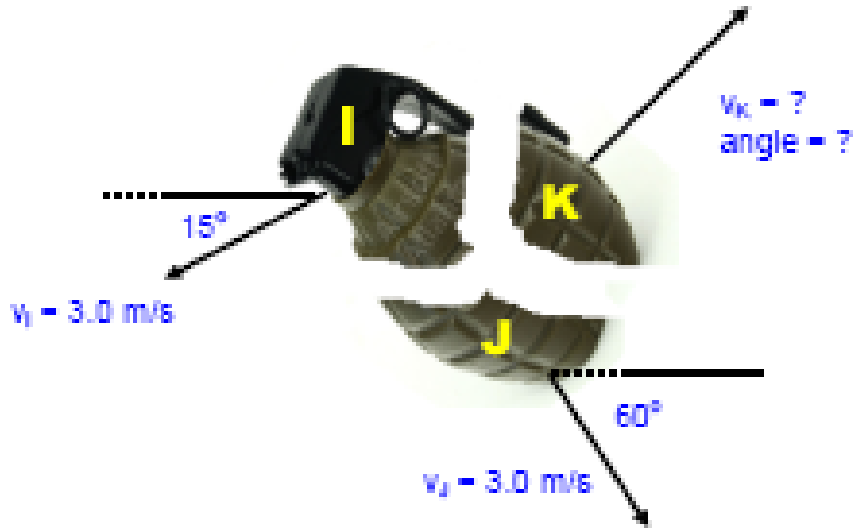






	Before			After		
	E	F	Total	E'	F'	Total'
p_x						
p_y						

Explosion: 3-triangle type



	Before				After			
	I	J	K	Total	I'	J'	K'	Total'
p_x								
p_y								