name:

group members:

SCIENCE ONE PHYSICS WORKSHEET: MOMENTUM

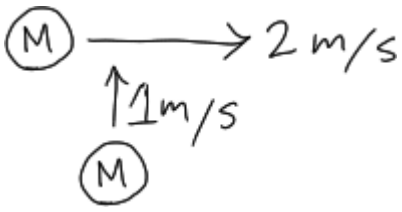
This LAW OF CONSERVATION OF MOMENTUM states:

> *For any physical system with translational symmetry in direction x, the total x momentum p_x in the system is unchanging in time.*

The same goes for y and z, so if there is complete translational symmetry (e.g. in outer space), the total p_x , p_y , and p_z are each constant in time. Equivalently, we can say that the vector quantity $\vec{p}$ is conserved.

For now, let's take our physical system to be one with multiple objects that may interact with one another. In this case, the total momentum is just the sum of the momenta for each of the objects.

Question 1



a) Suppose there is a collision between two blobs of space-goo, each with mass M and velocities as shown. If the blobs stick together, what is the final *velocity* of the resulting blob (give x and y components)?

b) In the first half of the 20th century, physicists were puzzled by certain kinds of nuclear decays in which a stationary nucleus decays into an electron and another nucleus, as shown below:

Why was such a decay puzzling? Can you think of a possible resolution to the puzzle?

Question 2

Somewhere in outer space, two identical space-rocks each collide (at identical velocity) with two different asteroids, one twice as heavy as the other. If the rocks bounce off at the same speed in each case, which asteroid has a larger change in momentum? Use your clicker to select one of the answers, and use the space below to write an argument based on momentum conservation.

Getting hit by a rock is a particular example of an external influence that can change the momentum of an object. In general, different external influences can have smaller or larger effects on an object. We'd now like to come up with a quantitative measure of how strong such an influence (e.g. a push or a pull) is.

Question 3

Suppose you are in outer space. You want to come up with a standard way to measure the strength of a push (e.g. to assign a number that quantifies how strong it is). What should you do?

Question 4

a) Imagine giving something a push (in outer space). On the axes below, make a sketch where the horizontal axis is time and the vertical axis is the momentum of the object

b) Indicate on your graph where you were pushing the hardest. What specific feature of your graph tells you this?

c) In physics-speak, we would use the term FORCE to indicate how hard we are pushing at a particular time. Based on your previous answer, come up with a definition of force in terms of some property of the momentum versus time graph. (Check your answer with an instructor).

d) Rewrite your answer to c) using the formula for momentum in terms of mass and velocity. You may use the fact that mass doesn't change with time.

e) If we applied the same force to a more massive object, how would the momentum versus time graph differ?

f) Apart from your definition in part c), can you think of another way to define force?

Question 5

Suppose two objects are interacting (e.g. during a collision when they are in contact with each other). In a certain small time interval Δt, the change in momentum of the first object is Δp_1.

(*answer all questions in terms of Δt and Δp_1*)

a) What is the change in momentum of the second object during the same amount of time?

b) What is the force on the first object (use your definition from Q4)?

c) What is the force on the second object?

Question 6

A small car pushes a large truck that has broken down. They are stuck together, so they have the same acceleration. Is the force of the car on the truck larger or smaller than the force of the truck on the car? Explain why your answer is consistent with Newton's second law.