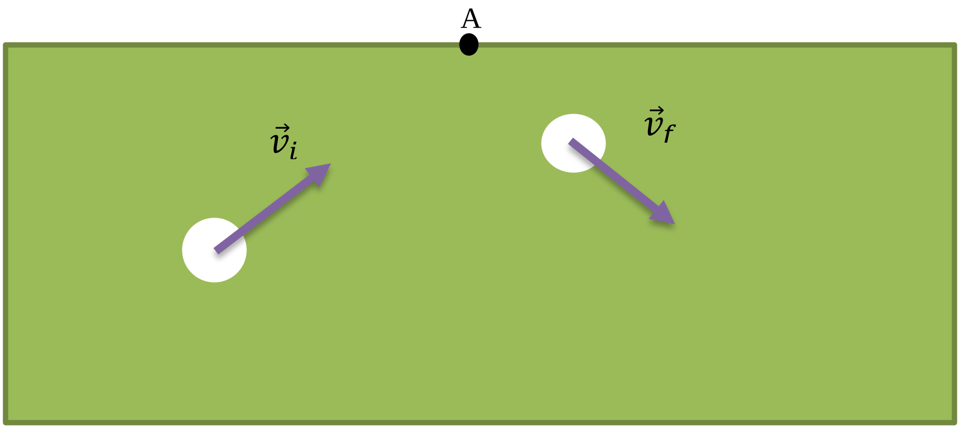
Name:____________

Wall-disk collisions in 2D

A. Calculating the force and acceleration vectors during the collision

A disk with a mass of 200 grams is placed on an air table at point $A(-2{,}0{,}0)$ m. The disk is hit, and given an initial velocity of $\vec{v}_i = (1{,}2{,}0)$ m/s. The disk moves at a constant speed and hits the wall of the table. Assume that the wall of the table acts on the disk with a **force of constant magnitude whose direction is perpendicular to the wall of the table**, and that the duration of the collision with the wall is 0.1 seconds.



1. A few lessons ago, we measured the motion of a cart moving on a track and colliding with the wall. We reached the conclusion that in the case of a 1-dimensional collision with the wall, when the force that the wall exerts during the collision is elastic or constant, the magnitude of the velocity is conserved and its direction is reversed. In the case here, the disk moves in a plane (it has a velocity in the x and y directions), and the force that the wall exerts on the disk during the collision acts only in the y direction.
   a. **Explain:** How (if at all) does the x component of the disk's velocity change during the collision?

   b. **Explain:** How (if at all) does the y component of the disk's velocity change during the collision?

c. Relying on your answers to the previous parts, **write** the velocity vector after the collision.

2. **Calculate** the acceleration vector $\vec{a}$ (during the collision) algebraically, and **sketch** it on the diagram (that appears above).

3. What is the direction of the force that the wall exerts on the disk? **Add a sketch** of the force vector to the diagram.

4. **Calculate** the magnitude of the force vector, given that the mass of the disk is 200 grams..

B. Planning the computational model

Below is a partial snippet of code for a disk colliding with a wall. **Complete** the blanks with code, and **match the problem conditions** to those described on the previous page in order to obtain a collision with the wall in which the force is constant. **Attention:** You will have to add lines and definitions as needed.

C. Building a computational model for a two-dimensional collision based on constant force.

1. Download the file “start here.py” from the website.

```
from visual import *

### System Creation ###

table = box(pos=(0,0,0), size=(10,10,0.05))
disk = cylinder(pos=(_______), radius=0.5, axis=(0,0,0.1))

###  Initial Conditions  ###

dt = 0.01
t = 0
v =________

###  Time Evolution  ###

while t < 5:
    rate(100)

    if __________________________ :F =
    else: F = _________

    a = ____________
    v = ____________
    disk.pos = ____________________

    t = t + dt
```

2. Complete the code according to your answers to the previous parts, and run it.
3. Prediction of the model: Did you get a simulation for the collision described in part A of the task? How can you determine this?
4. In order to precisely compare the prediction of the model that you built with the calculation that you did in the first part of the task, you can verify that the duration of the collision is 0.1 seconds. Calculate the duration of the collision by two methods:

a. Approximate method: Produce a velocity-time graph (which component of velocity is relevant?) and estimate from it the duration of the collision.
b. Exact method: Add a command (or commands) to the program you wrote, calculating the duration of the collision.

D. Building a computational model for a two-dimensional model based on elastic force.

1. Create a new program in which the disk-wall collision is elastic.
2. Find (by trial and error) the value of the spring constant for which the duration of the collision is 0.1 s.
3. Representing the velocity vector: Add an arrow to describe the velocity vector. Position the tail of the arrow at the center of the disk. The arrow should move along with the disk and describe the change in velocity during the collision.

E. To turn in

To turn in:

1. Parts A and B: Answer in writing and hand in manually.
2. Part C: A VPython file with a working simulation of the collision with the wall based on **constant force**.
3. Part D: VPython with a working simulation of the colllision with the wall based on **elastic force**.

Running the two files needs to display, in addition to the simulation, a velocity-time graph and print the duration of the collision.

Useful formulas

Physical quantity	Definition
Displacement	$\Delta\vec{x} = \vec{x}_f - \vec{x}_i$
Velocity	$\vec{v} = \frac{\Delta\vec{x}}{\Delta t}$
Acceleration	$\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$
Calculating position (by Euler's approximation)	$x_{i+1} = x_i + v \cdot dt$
Calculating velocity (by Euler's approximation)	$v_{i+1} = v_i + a \cdot dt$
Newton's Second Law	$\Sigma\vec{F} = m\vec{a}$
Hooke's Law (elastic force)	$\vec{F} = -k\Delta\vec{x}$