Student Autograde Results

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```
test5:
  AssertionError:
  Not equal to tolerance rtol=1e-07, atol=0

  Mismatched elements: 80 / 82 (97.6%)
  Max absolute difference: 0.4576732
  Max relative difference: 4.0454261
   x: array([[ 0.134623,  0.323096],
         [ 0.134623,  0.323096],
         [ 0.156388,  0.353793],...
   y: array([[ 0.134623,  0.323096],
         [ 0.156388,  0.353793],
         [ 0.182886,  0.388543],...
```

duplicated!

Test ID	Description	Status	Points
test0	always true	Passed	1
test1	test grav_acc	Passed	1
test2	test checkinit, |s| < Rp	Passed	1
test3	test checkinit, v_y0 < 0	Passed	1
test4	test sc_vel_pos_change	Passed	1
test5	test get_traj, acc	Failed: AssertionError	0
test6	test get_traj, vel	Passed	1
test7	test get_traj, pos	Passed	1
test8	test get_traj for checkinit	Passed	1
total/9	...	...	8

Normalized grade: 8.89 / 10

see below!

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In [1]:
```
import numpy as np
import math
import matplotlib.pyplot as plt

def grav_acc(s_x, s_y, planet_mass):
    '''
    takes in x,y components of position vector from the planet and mass of p
    finds acceleration components

    input: s_x, s_y, planet_mass
    output: a_x (m/s), a_y (m/s)
    '''
    s = math.sqrt(s_x**2 + s_y**2)
    #formula for a is GMp/s^2
    big_G = 6.67e-11
    a = (big_G*planet_mass)/(s**2)

    sin_beta = -(s_x)/s
    cos_beta = -(s_y)/s

    a_x = a * sin_beta
    a_y = a * cos_beta

    return(a_x, a_y)

def checkinit(s_x0, s_y0, v_x0, v_y0, planet_radius):
    '''
    Checks starting position, s, determined by inputs s_x0 and s_y0 against
    Checks v_y0 to ensure y-axis velocity is positive.
    '''
    s = math.sqrt(s_x0**2 + s_y0**2)
    if np.abs(s) <= planet_radius:
        raise ValueError('Please enter coordinates that are above the planet
    elif v_y0 < 0:
        raise ValueError('Please enter a positive velocity, in the directio
    else:
        pass

def sc_vel_pos_change(a_x, a_y, v_x, v_y, time_step):
    '''
    Takes in instantaneous acceleration and velocity x&y components at a cer
    Returns the delta(change) of x-y position vectors and velocity vectors t
    input: a_x, a_y, v_x, v_y, time_step
    output: ds_x, ds_y, dv_x, dv_y
    '''
    dv_x = a_x * time_step
    dv_y = a_y * time_step

    ds_x = v_x * time_step + 0.5*a_x*(time_step)**2
    ds_y = v_y * time_step + 0.5*a_y*(time_step)**2

    return ds_x, ds_y, dv_x, dv_y
```

```python
def get_traj(s_x0, s_y0, v_x0, v_y0, time_step, total_time, planet_mass, pla
    '''
    defines four arrays with the size of every time interval determined by t
    matches the instantaneous acceleration, velocity, and position determine
    returns data organized into x & y components, resulting in tracking of v

    inputs: s_x0, s_y0, v_x0, v_y0, time_step, total_time, planet_mass, plan
    output: arrays time, acc, vel, pos
    '''
    total_steps = int(total_time/time_step) + 1

    time = np.linspace(0, total_time, total_steps)

    acc = np.ones((time.size, 2))*np.nan
    vel = np.ones((time.size, 2))*np.nan
    pos = np.ones((time.size, 2))*np.nan
```

interesting choice...

```python
    checkinit(s_x0, s_y0, v_x0, v_y0, planet_radius)

    pos[0, 0] = s_x0
    pos[0, 1] = s_y0
    vel[0, 0] = v_x0
    vel[0, 1] = v_y0
    acc[0, 0], acc[0, 1] = grav_acc(pos[0, 0], pos[0, 1], planet_mass)
```

good!

```python
    for i in range(1, len(time)):
```

* handle initial values separately!

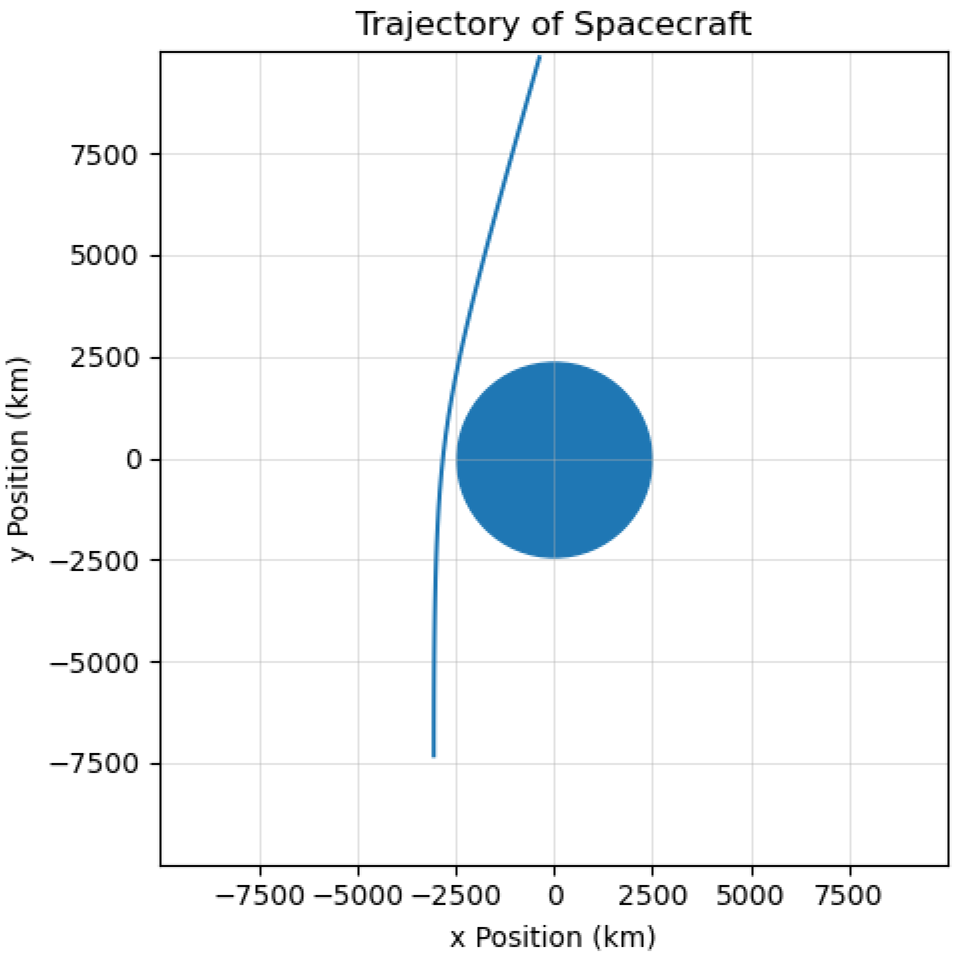
superfluous

```python
        a_x, a_y = grav_acc(pos[i-1, 0], pos[i-1, 1], planet_mass)

        acc[i, 0] = a_x
        acc[i, 1] = a_y
```

sets second element to initial element

```python
        ds_x, ds_y, dv_x, dv_y = sc_vel_pos_change(a_x, a_y, vel[i-1, 0], ve

        vel[i, 0] = vel[i-1, 0] + dv_x
        vel[i, 1] = vel[i-1, 1] + dv_y
        pos[i, 0] = pos[i-1, 0] + ds_x
        pos[i, 1] = pos[i-1, 1] + ds_y

    return time, acc, vel, pos

v_x0 = 0 #(m/s)
v_y0 = 7000 #(m/s)
time_step = 60
total_time = 40 * 60 #(s)
planet_mass = 3.3e23 #(kg)
planet_radius = 2440*1000 #(m)
s_x0 = -3050*1000 #(m)
s_y0 = -3*planet_radius #(m)

def mag(x, y):
    arr = np.ones(len(x)) * np.nan
    for i in range(len(x)):
        arr[i] = math.sqrt(x[i]**2 + y[i]**2)
    return arr
```

```
def find_lowest_altitude(x):
    return np.argmin(x)

time, acc, vel, pos = get_traj(s_x0, s_y0, v_x0, v_y0, time_step, total_time

fig, ax = plt.subplots(figsize = (5, 5))
ax.plot(pos[: , 0]/1000, pos[: , 1]/1000)
ax.set_xlim(-9999, 9999)
ax.set_ylim(-9999, 9999)
ax.set_xlabel("x Position (km)")
ax.set_ylabel("y Position (km)")
ax.set_title("Trajectory of Spacecraft")
ax.grid(True, alpha=0.5, which='both', linewidth=0.5, axis='both')
ax.scatter(0, 0, marker = "o", s = planet_radius/1000 * 2)

fig2, ((ax2), (ax3), (ax4)) = plt.subplots(3, 1, figsize = (10, 8))
fig2.tight_layout(pad = 5)
ax2.plot(np.arange(time.size), acc[:, 0], label='a_x')
ax2.plot(np.arange(time.size), acc[:, 1], label='a_y')
ax2.plot(np.arange(time.size), mag(acc[:, 0], acc[:, 1]), label='|a|')
ax2.set_xlabel("Time (min)")
ax2.set_ylabel("Acc. m/s^2")
ax2.set_title("Acceleration Due to Gravitational Force")
ax2.grid()
ax2.legend()

ax3.plot(np.arange(time.size), mag(vel[:, 0]/1000, vel[:, 1]/1000))
ax3.set_xlabel("Time (min)")
ax3.set_ylabel("Vel. km/s")
ax3.set_title("Spacecraft Speed")
ax3.grid()

altitude = mag(pos[:, 0]/1000, pos[:, 1]/1000) - planet_radius/1000
ax4.plot(np.arange(time.size), altitude)
ax4.set_xlabel("Time (min)")
ax4.set_ylabel("Altitude (km)")
ax4.set_title("Spacecraft Altitude ")
ax4.annotate(f"Closest approach: {np.round(np.min(altitude), 1)} km",
             (np.max(time)/120, (np.max(altitude) - np.min(altitude)) * 0.75
             fontsize = 10)
fig.tight_layout()
```


Trajectory of Spacecraft
y Position (km)
7500
5000
2500
0
−2500
−5000
−7500
−7500 −5000 −2500 0 2500 5000 7500
x Position (km)

lovely plots!