## EOSC 211: Some Numerical Integration - Assignment 2 background

**Movies**

Sketch how you think the spacecraft’s flight path and speeds in the two other trajectories will compare with the one shown.

**Sketching out the Problem:**

**1.** sketch the direction of the force and acceleration on the spacecraft in A.

Planet

B

v

Planet

A

2. sketch the spacecraft’s position, velocity and acceleration at some time t = t later in B.

**Calculations**:

We will use the initial conditions from Part 5 of the assignment:

sx0 = -3050 km

sy0 = -3 \* Rmerc

vy0 = 7 km/s in the positive y-direction

vx0 = 0

The values for the mass and radius of Mercury and the gravitational constant, G, are

Mmerc = 3.3 x1023 kg

Rmerc = 2440 km

G = 6.67 x10-11 m3 kg-1 s-2

**Step 1:** Fill in the initial conditions – ie the x-y coordinates of speed and position of the spacecraft at time t=0 in cols 5-8 of row 1 of the table. Calculate, s the distance of the spacecraft from the planet, and s2.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **t (s)** | **vx (m/s)** | **vy (m/s)** | **sx (m)** | **sy (m)** | **vx (m/s)** | **vy (m/s)** | **sx**  **(m)** | **sy**  **(m)** | **s2 (m)** | **a (m/s2)** | **ax (m/s2)** | **ay (m/s2)** |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| **0** | **XXX** | **XXX** | **XXX** | **XXX** |  |  |  |  |  |  |  |  |
| **60** |  |  |  |  |  |  |  |  |  |  |  |  |
| **120** |  |  |  |  |  |  |  |  |  |  |  |  |

**Step 2:** Calculate the magnitude of the acceleration, a, on the spacecraft at time, t=0 due to the planet and add it to the table above. Resolve the acceleration into its x- and y- coordinates and fill these in (ax and ay).

**Step 3:** If we assume the acceleration is constant over a time interval t, then after the time t there is a change in velocity due to this acceleration. This is in the direction of the acceleration vector so the easiest thing is to work in terms of the x- and y- components of the change in velocity.

Write down the equations for the x- and y- components of the *change in velocity* in terms of the x- and y- components of acceleration and the time interval t.

vx = \_\_\_\_\_\_\_\_\_\_\_ vy = \_\_\_\_\_\_\_\_\_\_\_

Similarly there is a change in position, which depends both on the velocity at the beginning of the time interval and on the acceleration:

sx = vx t + ½ ax t2 sy = vy t + ½ ay t2

Fill in these changes in velocity and position (occurring after 60 seconds) in row 2, columns 1-4 of the table.

**Step 4:** The new velocity after a time t is the initial velocity plus the change in velocity.

So in our table above we can calculate the x- and y-components of velocity at t=60 seconds using

vxt=60 = vxt=0 + vx vyt=60 = vyt=0 + vy

and the x- and y- components of position at t= 60 seconds using

sxt=60 = sxt=0 + sx syt=60 = syt=0 + sy

Calculate the new vx, vy, sx, sy and fill in columns 5-8 of the second row of the table.

**Step 5:** You can now see that you can essentially repeat steps 2-4 for each successive 60 seconds of the spacecraft’s trajectory using Steps 2-4 above. To calculate the entire spacecraft trajectory you would repeat steps 2-4 until you have reached a time t = tfinal (given as 40 minutes in part 5 of the assignment). **Hint:** If you do this by hand (correctly!) for the first 3 rows given you can of course check your MATLAB code using this table….