AST1100
Oblig11
Lecture 17 - Problem 2
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The assignment this week is to model the path of a spaceships towards a black hole. This is done using the geometry of spacetime instead of forces. There's not much to explain this week since the assignment is done step by step through the exercise. All the values used are either given in the text or taken from the solution for the last exercise. This means that pretty much all there is to show for this week is the python code I made. There are comments in the code which explain what each section of code does.

Here's a quick explanation of the problem:
We are to start the spaceship at a distance $r = 20M$ from the blackhole with an angle $phi = 0$. We then evolve the position of the ship using equations 2 and 3 from the lecture notes. The only question that we get is what the final angle of the ship is. The answer to that can be read in the part with the output of the program in the end.

```
from scitools.all import *

#Constants
M              = 1
n              = 1000
dtau           = 0.01
Spin           = 38*M
Energypermass = 8.03

#Arrays
r       = zeros(n)
phi     = zeros(n)
x       = zeros(n)
y       = zeros(n)

#Initial Conditions
r[0]       = 20
phi[0]     = 0

# Calculate path of spaceship
for i in range(n-1):
    if r[i] >= 2:
        dphi = Spin/r[i]**2*dtau
        dr   = -sqrt( (Energypermass**2) - (1+ ((Spin/r[i])**2)
    *(1-2*M/r[i])))*dtau
        phi[i+1] = phi[i] + dphi
        r[i+1] = r[i] + dr
    else:
        print "Final phi: ", phi[i]/pi*180
        break

#Convert to Cartesian:
for i in range(n):
    x[i] = r[i]*cos(phi[i])
    y[i] = r[i]*sin(phi[i])

#Plot path of spaceship
plot(x,y,'ro')
hold('on')

#Plot eventhorizon of blackhole
rs     = zeros(100)
xs     = zeros(len(rs))
ys     = zeros(len(rs))
rs[:] = 2
phis = linspace(0,2*pi,len(rs))
for i in range(len(rs)):
     xs[i] = rs[i]*cos(phis[i])
```

```
    ys[i] = rs[i]*sin(phis[i])
plot(xs,ys,'b-')
xlabel("x-axis[Units of M]")
ylabel("y-axis[Units of M]")
hardcopy("oblig11.png")
```

oblig11.py

After the code is run we get the following output:
Final phi: 202.784147091

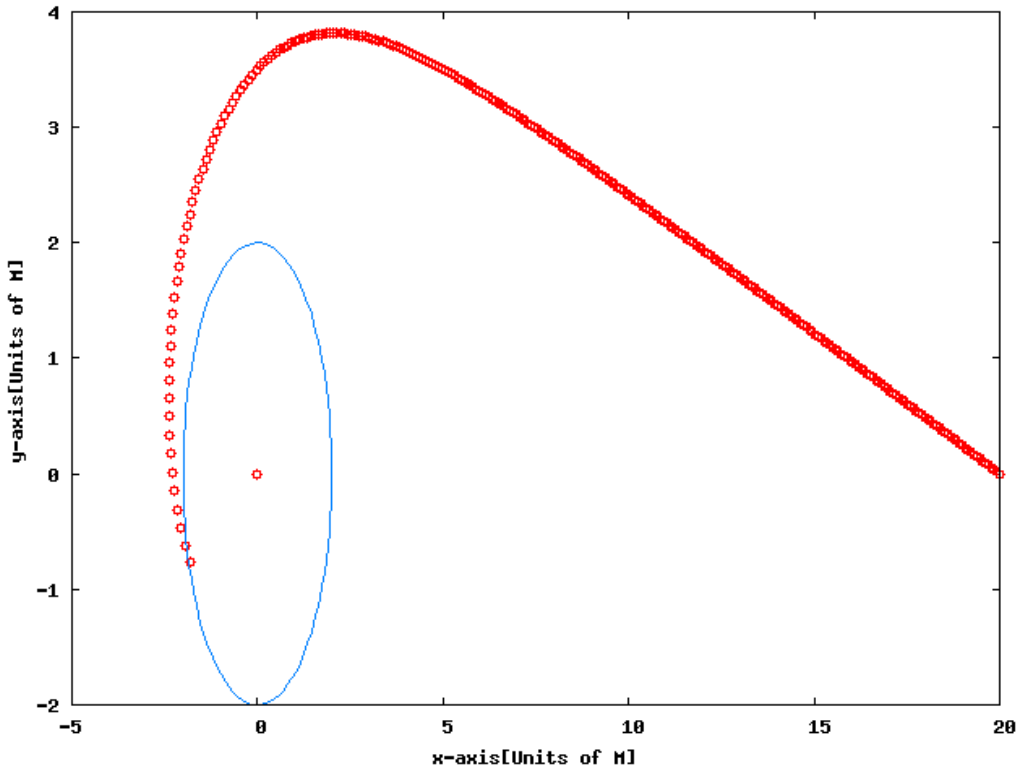

Figure 1: Path of the spaceship

Conclusion:
The final angle corresponds to the point where the spaceship enters the event horizon on the plot. This is as expected.
The spaceship starts out going in the direction it did in the first exercise. This is as expected.
The path looks like the path gravity would force the spaceship to go so I guess I've done this right.