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% program to shoot a rocket to the moon and to boost it into orbit around
% the moon

G=6.7e-11;                % gravitational constant
mEarth = 5.9742e24;       % mass of the earth
rEarth = 6.378e6;         % radius of the earth

rMoon = 1.737e6;          % radius of moon
mMoon = 7.35e22;          % mass of moon
rMoonOrbit = 385000000;   % radius of moon orbit
vM=1025.;                 % moon velocity

% rocket launch velocity and # of days to reach moon orbit
% previously determined by trial and error
RDAYS = 3.9;
%VEL = 11170 - 55 ;  % hit the moon
VEL = 11170 - 55.30 ;  % just miss

% position moon theta radians off y axis, where theta =
% the number of radians the moon travels in RDAYS calculated offline
theta = .8976;
x(1) = rMoonOrbit*cos(pi/2 - theta);   % initial x position
y(1) = rMoonOrbit*sin(pi/2 - theta);   % initial y position
vx(1) = vM*cos(pi - theta);   % rotate velocity vector
vy(1) = vM*sin(pi - theta);   % pi/2 radians counterclockwise

% initial parameters for rocket, launch rocket staight up y axis
xR(1) = 0;        % initial x position
yR(1) = rEarth;   % initial y position at alt. 300km
vxR(1) = 0;       % initial x velocity
vyR(1) = VEL;   % initial x velocity

% guidance parameters, boost starts when rocket reaches moon alt.
% determined by trial and error to slow down rocket so it goes into orbit
% around moon
yBoost=  -8.3;
Btimer = 0;  Blimit = 120;

t(1) = 0;                       % start time
dt=1;
fti = 4.5*24*60*60 / dt;        % # of iterations to fly 4.5 days

for i=1:fti
    t(i+1) = t(i) + dt;        % time at start of interval i+1

    % project moon position and velocity
    R = sqrt(x(i)^2+y(i)^2);  % earth/moon distance
    Ag = G*mEarth/R^2;        % moon accel at start of interval i
    x(i+1) = x(i) + vx(i)*dt;  % x at start of interval i+1
    y(i+1) = y(i) + vy(i)*dt;  % y at start of interval i+1
    vx(i+1)= vx(i) - Ag*(x(i))/R*dt;  % moon x velocity
    vy(i+1)= vy(i) - Ag*(y(i))/R*dt;  % moon y velocity
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    % project rocket position and velocity
    R = sqrt(xR(i)^2+yR(i)^2);   % earth/rocket distance
    Ag = G*mEarth/R^2;          % rocket accel due to earth
    Rm = sqrt((xR(i)-x(i))^2+(yR(i)-y(i))^2); % moon/rocket distance
    Agm = G*mMoon/Rm^2;          % rocket accel due to moon
    xR(i+1) = xR(i) + vxR(i)*dt;  % x at start of interval i+1
    yR(i+1) = yR(i) + vyR(i)*dt;  % y at start of interval i+1
    vxR(i+1)= vxR(i) - Ag*xR(i)/R*dt - Agm*(xR(i) - x(i))/Rm*dt;
    vyR(i+1)= vyR(i) - Ag*yR(i)/R*dt - Agm*(yR(i) - y(i))/Rm*dt;

    if (Rm < rMoon) % has rocket hit the moon ?
        break
    end;

    % apply boost when rocket reaches moon altitude
     if (R>rMoonOrbit && Btimer <= Blimit)
       vyR(i+1) = vyR(i+1) + yBoost;
       Btimer = Btimer + dt;
    end

end

 II=[i+1-80000:i+1];  % graph last 80000 points

plot(x(II),y(II))
hold on
plot(xR(II),yR(II))

% draw a circle for the moon at its last location
for j=1:101
   ang=2*pi*j/100;
   xG(j)= rMoon*cos(ang);
   yG(j)= rMoon*sin(ang);
end
plot(xG + x(i),yG + y(i))  % draw the moon
hold off
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