University of Dhaka

Department of Applied Mathematics

Third Year B.S. (Honors), Academic Session: 2022-2023

Course Title: Math Lab III (MATLAB), Course Code: AMTH 350

Assignment No.: 5

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Instruction: Write an appropriate programming code using **MATLAB** software to get the output of each problem and hence visualize them properly.

1. A projectile is fired with an initial velocity of $280 m/s$ at an angle of $\theta = 55^0$ relative to the ground. The projectile is aimed directly North. Because of a strong wind blowing to the West, the projectile also moves in the direction at a constant speed of $35 m/s$. Determine and plot the trajectory of the projectile until it hits the ground. For comparison, plot also the trajectory that the projectile would have had if there was no wind.

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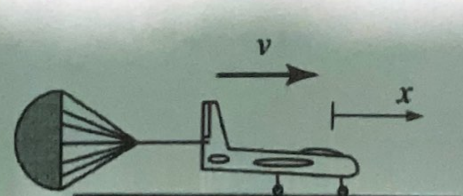
2. A safety bumper is placed at the end of a racetrack to stop out-of-control cars. The bumper is designed such that the force that the bumper applies to the car is a function of the velocity v and the displacement x of the front edge of the bumper according to the equation: $F = Kv(x+1)^3$, where $K = 40 s-kg/m^5$ is a constant. A car with a mass m of $1700 kg$ hits the bumper at a speed $80 km/h$. Determine and plot the velocity of the car as a function of its position for $0 \le x \le 5$ meter.

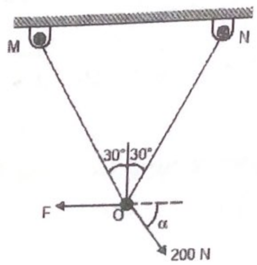
An airplane uses a parachute and other means of braking as it slows down on the runway after landing. Its acceleration is given by $a = -0.0035v^2 - 3\ m/s^2$. Since $a = \frac{dv}{dt}$, the rate of change of the velocity is given by: $\frac{dv}{dt} = -0.0035v^2 - 3$. Consider an airplane with a velocity $300 km/h$ that opens its parachute and starts decelerating at $t = 0$ second.



(a) By solving the differential equation, determine and plot the velocity as a function of time from $t = 0$ second until the airplane stops.

(b) Use numerical integration to determine the distance x the airplane travels as a function of time. Make a plot of x versus time.

4. The following figure shows the two cables MO and NO tied together at O and the loadings are also shown. The magnitude of F is $150N$.

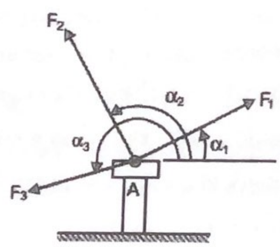


(a) Derive the expressions relating the tension in each cable as a function of α.

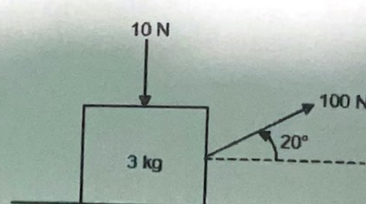
(b) Write a MATLAB program to plot the tension in each cable for $0^0 \le \alpha \le 90^0$.

(c) Determine the smallest value of α for which both cables are in tension.

5. Write a MATLAB program to determine the magnitude and direction of the resultant of three coplanar forces applied at a point A shown in the following figure. Use the following values: $F_1 = 20kN$, $F_2 = 40kN$, $F_3 = 200kN$, $\alpha_1 = 40^0$, $\alpha_2 = 25^0$, $\alpha_3 = 58^0$.



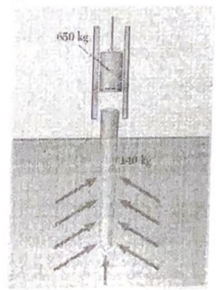
6. A 3 kg block is subjected to two forces as shown in the following figure. If block starts from rest, determine the distance it has moved when it attains a velocity of $10m/s$. Use a suitable MATLAB program to plot its distance as a function of coefficient of kinetic-friction between the block and floor.



7. A car has a mass of 1700 kg, a drag coefficient of 0.35, a rolling resistance coefficient of 0.01, a frontal area of 2 m^2, and a horsepower of 150. What is the minimum time required for the car to go from 0 to 60 mph? What is the minimum time if the car has 300 horsepower, with all else the same? Use a density of air of 1.2 kg/m^3, and $g = 9.8\ m/s^2$. Assume the car is on a perfectly flat surface and assume that the wheels don't slip.

8. An inflated basketball has a mass of 0.624 kg and a radius of 0.119 m. Find the effective gravity acting on the basketball, given a density of air of 1.2 kg/m^3, and $g = 9.8\ m/s^2$.

9. The 650-kg hammer of a drop-hammer pile driver falls onto the top of a 140-kg pile. After the impact, the hammer and the pile stick together and have a velocity of 3 m/s. The vertical force exerted on the pile by the ground after the impact is given by $F = 0.02x^2$, where x and F are expressed in mm and kN, respectively. Determine the velocity of the system after it has penetrated 80 mm into the ground.

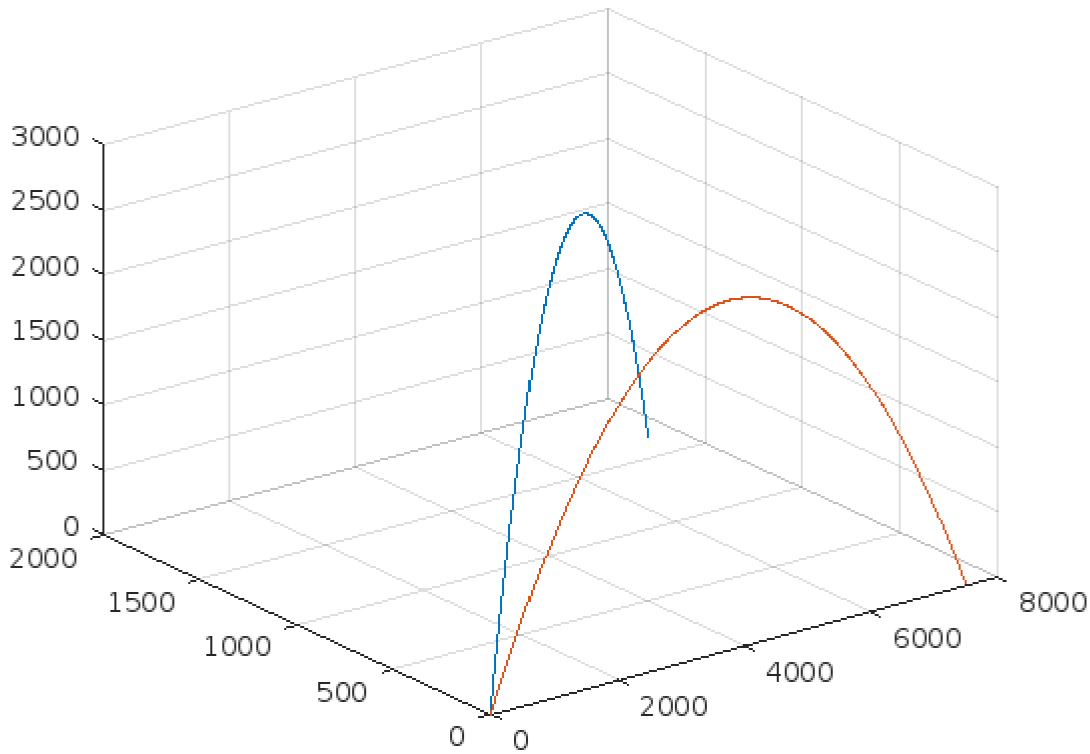


10. A rocket of initial mass m_0 *(including shell and fuel)* is fired vertically at time $t = 0$. The fuel is consumed at a constant rate $q = \frac{dm}{dt}$ and is expelled at a constant speed u relative to the rocket. Derive an expression for the magnitude of the velocity of the rocket at time t, neglecting the resistance of the air. Assuming $u = 2200$ m/s and escape velocity $v_m = 11.18$ km/s, obtain m_0/m_s and answer how much fuel we need to use to project each kilogram of the rocket shell into space.

```
%Assignment_5_Question_1
 clc;clear all;
 u_Y=280*sind(55);
 syms t
 Trajectory = eval(vpasolve(u_Y-0.5*9.8.*t==0,t))
 T=0:0.1: Trajectory;
 x=280*cosd(55)*T;
 y=u_Y*T-0.5*9.8.*T.^2;
 z=0.*T;
 w=35*T;
 plot3(x,w,y,x,z,y);
 grid on
```

```
Trajectory =

   46.8087
```



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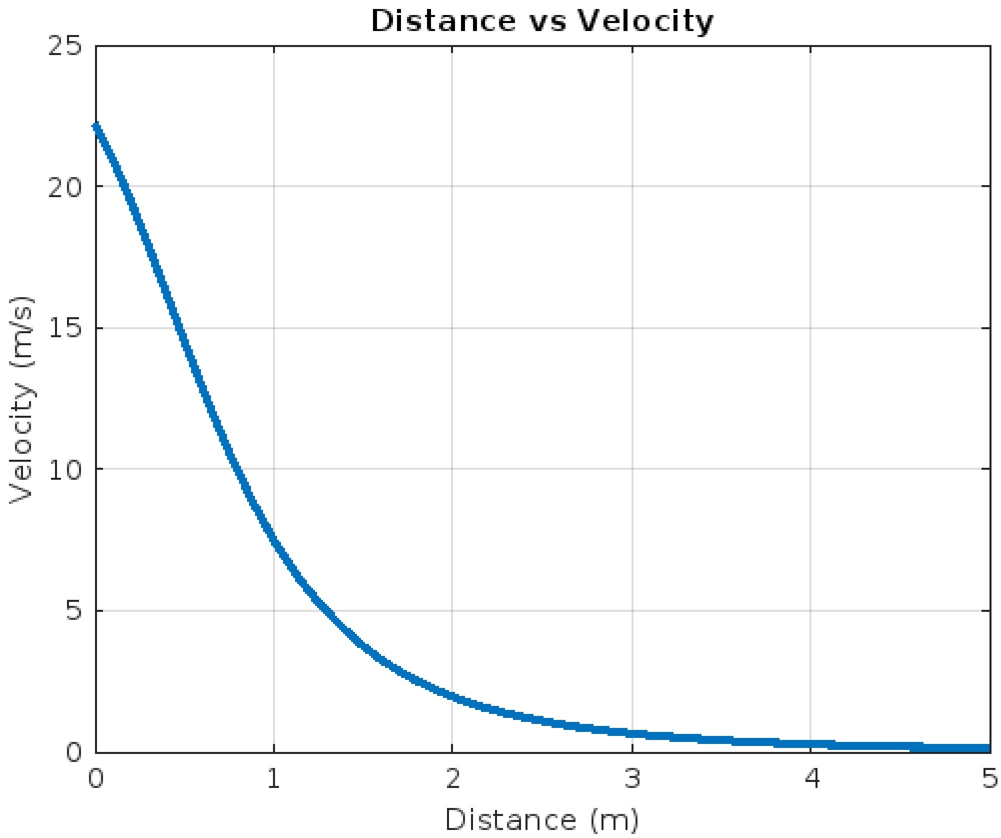
```
%Assignment 5 question 2
m=1700;
v_int=80/3.6;
func=@(x,v)(-40*v.^2.*(x+1).^3)./m;
[x,v]=ode45(func,[0,5],v_int);
plot(x, v, 'LineWidth', 3);
xlabel('Distance (m)')
ylabel('Velocity (m/s)')
title('Distance vs Velocity')
grid on
```



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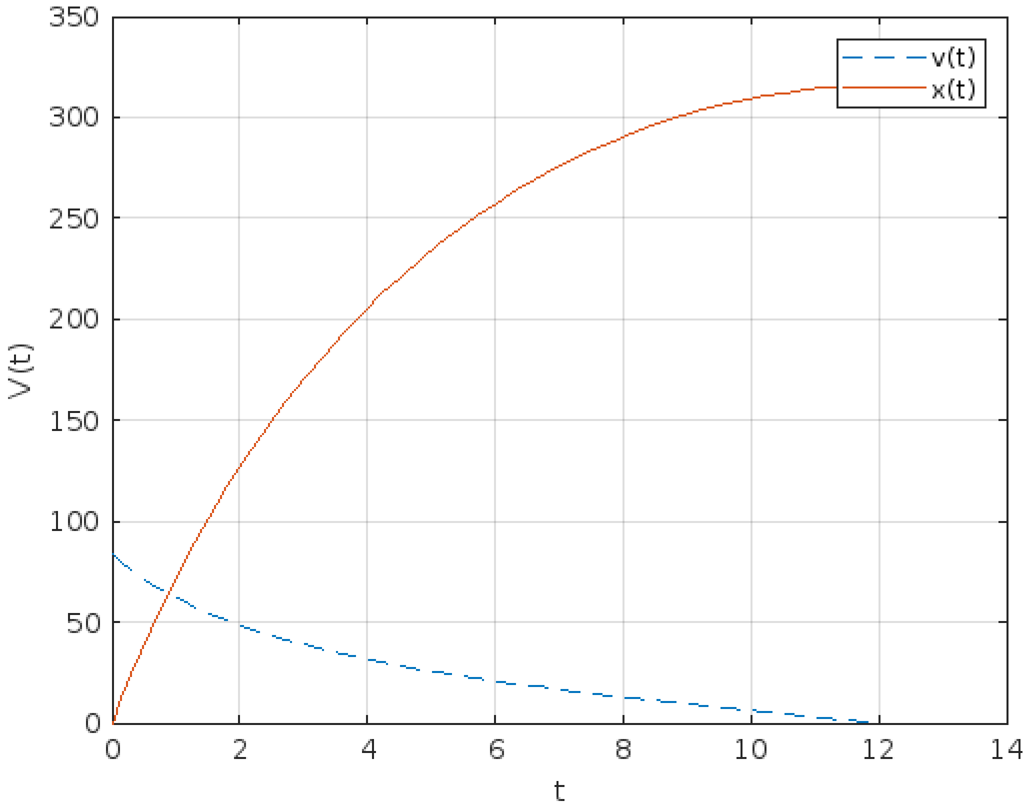
```
%Assignment 5 question 3
v_initial=300/3.6;
treq=integral(@(v) 1./(-0.0035.*v.^2-3),v_initial,0);
tspan=[0 treq];
[t v]=ode45(@(t,v) (-0.0035.*v.^2-3),tspan,v_initial);
plot(t,v,'--');
hold on
x=cumtrapz(t,v);
plot(t,x);
grid on
xlabel("t");
ylabel("V(t)");
legend("v(t)","x(t)");
```



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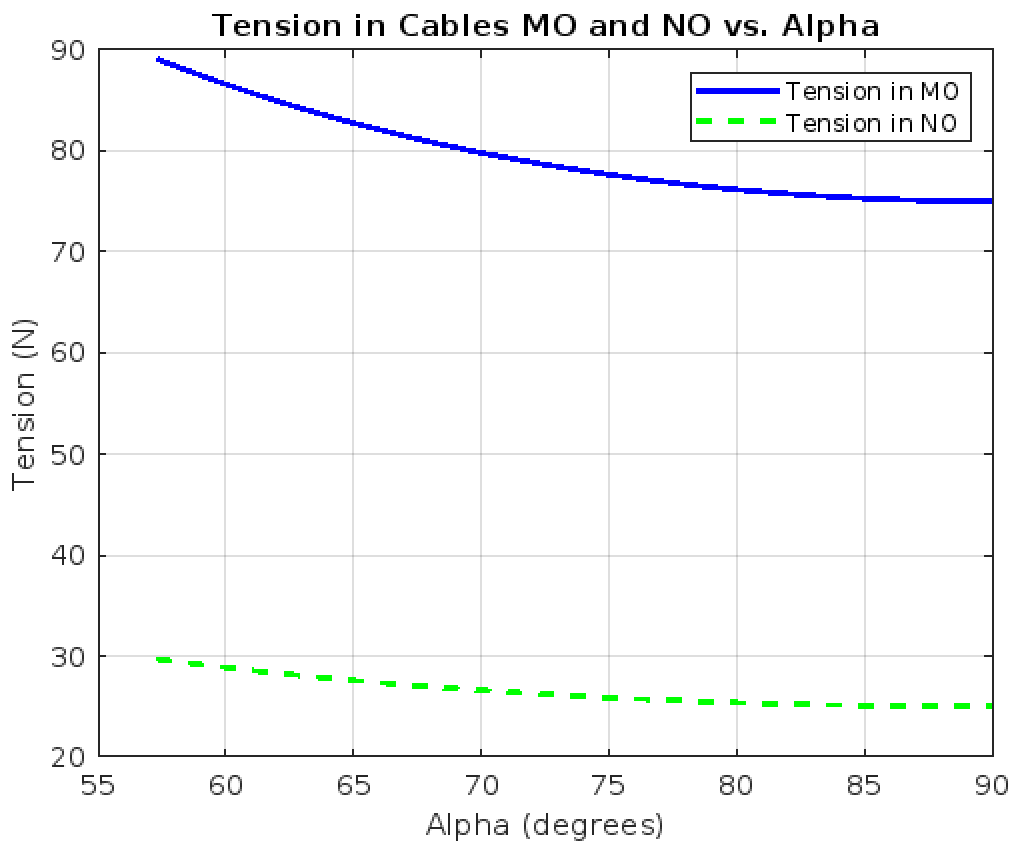
```
%Assignment_5_Question_4
clc; clear all;
F = 150; alpha = linspace(1, pi/2, 100); T_MO = F ./ (2 * sin(alpha));
T_NO = (1/3)*T_MO;
plot(rad2deg(alpha), T_MO, 'b-', 'LineWidth', 2);
hold on;
plot(rad2deg(alpha), T_NO, 'g--', 'LineWidth', 2);
xlabel('Alpha (degrees)');
ylabel('Tension (N)');
title('Tension in Cables MO and NO vs. Alpha');
legend('Tension in MO', 'Tension in NO');
grid on;
hold off;
tension_function = @(alpha) F./(2*sin(alpha));
smallest_alpha = fzero(tension_function, 0.1);
disp(['Smallest value of alpha for which both cables are in tension: ',
num2str(rad2deg(smallest_alpha)), ' degrees']);
```

```
Smallest value of alpha for which both cables are in tension: 3.1962e-14
degrees
```



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```
%Assignment_5_Question_5
clc;clear all;
F1 = 20; F2 = 40; F3 = 200;
alpha1 = deg2rad(40);
alpha2 = deg2rad(25);
alpha3 = deg2rad(58);

F1_x = F1 * cos(alpha1);
F1_y = F1 * sin(alpha1);
F2_x = F2 * cos(alpha2);
F2_y = F2 * sin(alpha2);
F3_x = F3 * cos(alpha3);
F3_y = F3 * sin(alpha3);
R_x = F1_x + F2_x + F3_x;
R_y = F1_y + F2_y + F3_y;
R_mag = sqrt(R_x^2 + R_y^2);
R_direction = atan2d(R_y, R_x);
disp(['Magnitude of the resultant force: ', num2str(R_mag), ' kN']);
disp(['Direction of the resultant force: ', num2str(R_direction), '
degrees']);
```

```
Magnitude of the resultant force: 254.1115 kN
Direction of the resultant force: 51.6816 degrees
```

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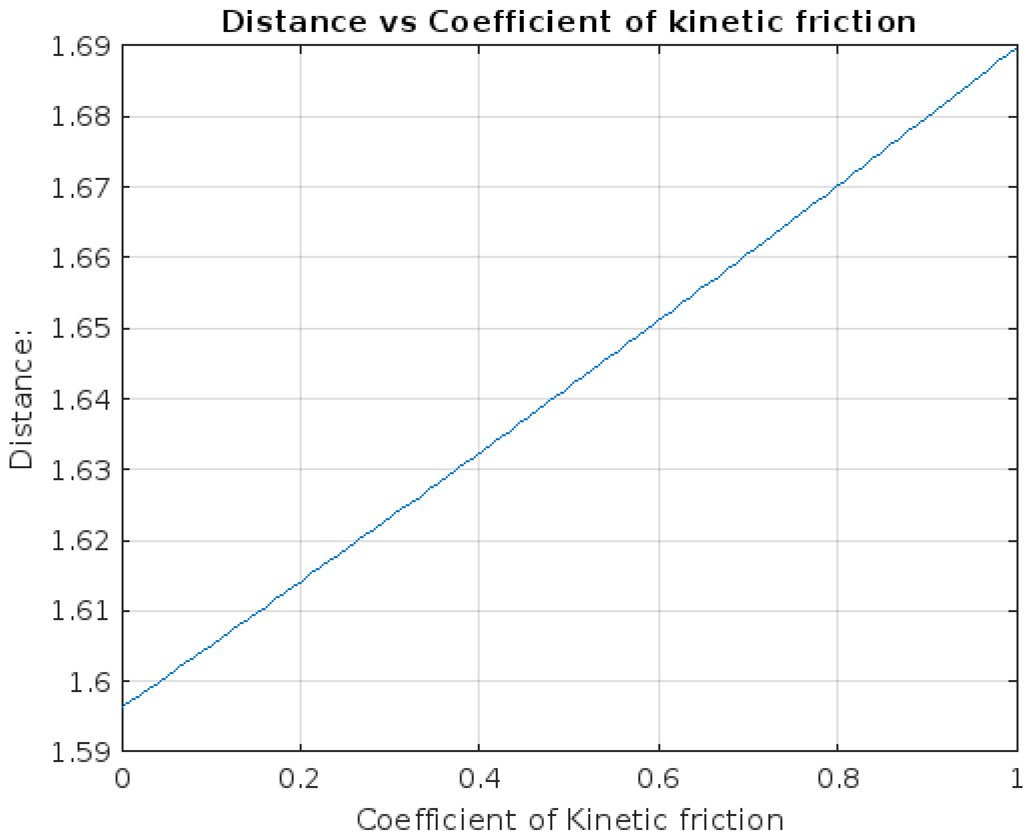
```
%Assignment_5_Question_6
clc;clear all;
m=3;
F_down=10;
F_pull=100;
g=9.8;
mu=linspace(0,1,100);
x=zeros(1,length(mu));
for i=1:length(mu)
N=m*g+F_down-F_pull*sind(20);
F=F_pull*cosd(20)-mu(i)*N;
a=F/m;
t=10/a;
x(i)=0.5.*a.*t.^2;
end
figure;
plot(mu,x);
xlabel('Coefficient of Kinetic friction');
ylabel('Distance:');
title('Distance vs Coefficient of kinetic friction');
grid on;
```

```
ans =

     1
```



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```
%Assignment_5_Question_7
clc;clear all;
v=60*1.6*(5/18);
m=1700;
cd=0.35;
cr=0.01;
a=2;
p1=150*745.7;
p2=300*745.7;
rho=1.2;
g=9.8;
F_drag=0.5*cd*a*rho*v^2;
F_rr=cr*m*g;
F_total=F_drag-F_rr;
a=F_total/m;
s=v^2/(2*a);
t1=(F_total*s)/p1;
t2=(F_total*s)/p2;
fprintf('Minimum time required for the car to go from 0 to 60 mph with 150
horsepower: %.6f seconds\n', t1);
fprintf('Minimum time required for the car to go from 0 to 60 mph with 300
horsepower: %.6f seconds\n', t2);
```

```
Minimum time required for the car to go from 0 to 60 mph with 150 horsepower:
5.403821 seconds
Minimum time required for the car to go from 0 to 60 mph with 300 horsepower:
2.701911 seconds
```

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```
%Assignment_5_Question_8
clc;clear all;
mass_basketball = 0.624;
radius_basketball = 0.119;
density_air = 1.2;
g = 9.8;
volume_basketball = (4/3) * pi * radius_basketball^3;
volume_displaced = volume_basketball;
buoyant_force = density_air * volume_displaced * g;
effective_gravity = g - (buoyant_force / mass_basketball);
fprintf('The effective gravity acting on the basketball is %.2f m/s^2\n',
effective_gravity);
```

```
The effective gravity acting on the basketball is 9.67 m/s^2
```

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```
%Assignment_5_Question_9
clc;clear all;
m_hammer = 650; % unit in kg
m_pile = 140; % unit in kg
v_initial = 3; % unit in m/s
x = 80 / 1000;
F = @(x) 0.02 * x.^2;
work_done = integral(F, 0, x);
delta_K = work_done;
K_final = 0.5 * (m_hammer + m_pile) * v_initial^2;
v_final = sqrt(2 * delta_K / (m_hammer + m_pile));
fprintf('Velocity of the system after penetrating 80 mm into the ground:
%.10f m/s\n', v_final);
```

```
Velocity of the system after penetrating 80 mm into the ground: 0.0000929589
m/s
```

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```
%Assignment_5_Question_10
syms m0 q t;
u=2200;
ve=11180;
v=u*log(q/(m0-q*t));
m0_ms=exp(ve/u);
fuel_per_kg=1-(1/m0_ms);
disp(['Velocity at time t is : ',char(v),'m/s']);
disp(['m0/ms : ',num2str(m0_ms)]);
disp(['Fuel used to project each kilogram rocket shell into space : ',
num2str(fuel_per_kg),'kg']);
```

```
Velocity at time t is : 2200*log(q/(m0 - q*t))m/s
m0/ms : 161.0666
Fuel used to project each kilogram rocket shell into space : 0.99379kg
```

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