

MATLAB Marina: Plotting 3D

Student Learning Objectives

After completing this module, one should:

1. Be able to generate and appropriately annotate 3D plots using MATLAB.

Terms

3D plot, linear 3D plot, parametric plot

MATLAB Functions, Keywords, and Operators

figure, plot3, xlabel, ylabel, zlabel, title, legend, gtext, grid, axis, clf, close, view

Linear 3D Plots

Linear 3d plots are plots of coordinates in 3D space. The MATLAB function `plot3` can be used for linear 3D plots. Linear parametric 3D plots are plots where the x, y, and z coordinates are functions of an independent variable or variables often time or position.

Consider 3D projectile motion, the x-position, y-position, and z-position of the projectile are all functions of the independent variable time and the projectile motion can be presented as a linear 3D plot. The kinematic equations for motion in three dimensions are:

Displacement s as a function of time:

$$s_x = s_{x0} + v_{x0}t + \frac{1}{2}a_x t^2$$

$$s_y = s_{y0} + v_{y0}t + \frac{1}{2}a_y t^2$$

$$s_z = s_{z0} + v_{z0}t + \frac{1}{2}a_z t^2$$

Velocity v as a function of time):

$$v_x = v_{x0} + a_x t$$

$$v_y = v_{y0} + a_y t$$

$$v_z = v_{z0} + a_z t$$

Where s is position (s_0 is the initial position), v is velocity (v_0 is the initial velocity), a is acceleration, and t is time. The subscripts x, y, and z indicate the direction for each of the components.

Figure 1a shows the MATLAB program used to create the 3D plot of projectile motion of Figure 1b.

```

% 3d projectile motion
% initial position
sx0 = 0.0;
sy0 = 0.0;
sz0 = 0.0;
% initial velocities for angle 45 degrees with respect
% to both xy and yz planes
vx0 = 100*cos(pi/4)*sin(pi/4);
vy0 = 100*sin(pi/4)*sin(pi/4);
vz0 = 100*cos(pi/4);
% acceleration due to gravity
ax = 0.0;
ay = 0.0;
az = -9.8; % gravity in m/s^2

% projectile motion for t = 0 to 14 seconds
t = 0.0 : 0.01 : 14.0;
sx = sx0 + vx0*t + 0.5*ax*t.*t;
sy = sy0 + vy0*t + 0.5*ay*t.*t;
sz = sz0 + vz0*t + 0.5*az*t.*t;

% parametric 3D plot of position
figure(1)
plot3(sx,sy,sz,'Linewidth',2);
grid, view(-37.5,30);
xlabel("x (m)"), ylabel("y (m)"), zlabel("z (m)");
title("3D Projectile Motion");

```

Figure 1a. MATLAB Program to Create Linear Parametric 3D Plot

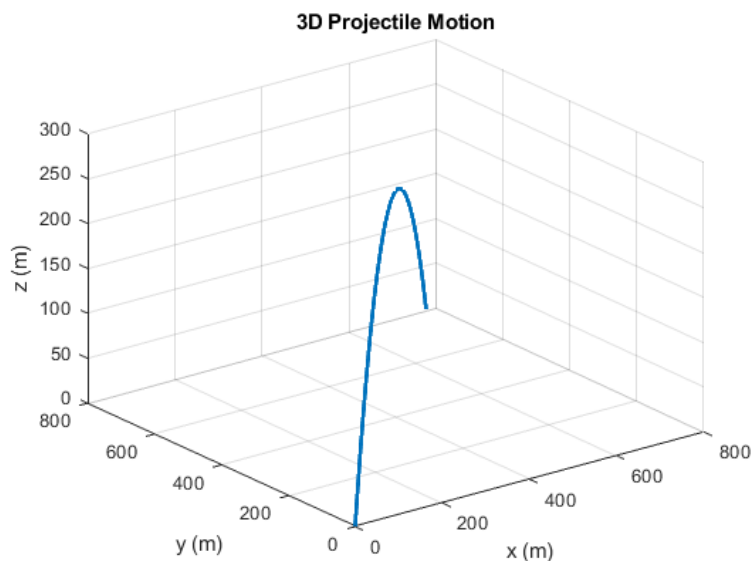


Figure 1b. Plot of 3D Projectile Motion

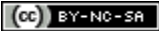
MATLAB allows one to specify the viewing angle of plots. The viewing angle can be specified for both 2D and 3D plots. The MATLAB function `view(azimuth, elevation)` allows one to specify the angle and elevation one sees the plot from. The azimuth is horizontal rotation in degrees (about the z-axis) and the elevation is the vertical elevation in degrees. Positive azimuth angles correspond to rotation counterclockwise about the z-axis. Positive elevation values correspond to viewing from above and negative values of elevation viewing from below.

Some common azimuths and elevations are:

- azimuth = 0, elevation = 90 is directly overhead and the default 2-D view.
- azimuth = elevation = 0 looks directly up the first column of the matrix.
- azimuth = 180 is behind the matrix.
- `view(2)` sets the default 2-D view, azimuth = 0, elevation = 90.
- `view(3)` sets the default 3-D view, azimuth = -37.5, elevation = 30.

The viewing angle can also be set from the axis properties of the figure window: Edit – Axes Properties. From the Axes Properties choose More Properties and the viewing angle can be altered by changing the view property. The rotate tool (counterclockwise circular arrow) on the figure window toolbar can also be used to change the viewing angle.

Last modified Friday, September 25, 2020

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