ME 8213 – Fall 2023
Homework #4

- Recommended format is 1 or more files of raw code for each problem + 1 word document containing a brief report of your results and comments. Code may be in any language/software.

Problem 1:

Compute the approximate value of

$$\int_{-1}^{1}\int_{-1}^{1} e^{-(x^2+y^2)}dx\,dy$$

using Gauss-Legendre quadrature. The exact value to 6 decimal places is 2.230985. What integration order is necessary to get agreement to this precision?

Problem 2: A ball of mass m = 0.25 kg is launched with initial velocity v_0 = 50 m/s at an angle 30° above the horizontal. Assuming the drag force acting on the ball is given by $F_D = C_D v^{\frac{3}{2}}$, the equations describing the motion in the horizontal and vertical directions are:

$$\ddot{x} = -\frac{C_D}{m}\dot{x}v^{\frac{1}{2}} \qquad \ddot{y} = -\frac{C_D}{m}\dot{y}v^{\frac{1}{2}} - g$$

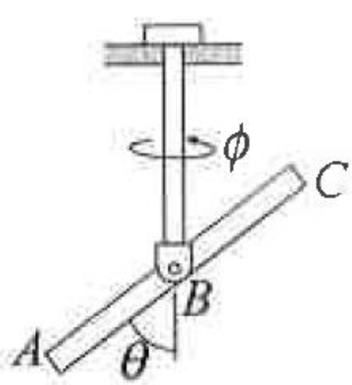
where v is the magnitude of the velocity ($v = \sqrt{\dot{x}^2 + \dot{y}^2}$). Using a Runge-Kutta method, determine the time before the ball hits the ground and how far away it lands from where it was launched. Use $C_D = 0.03\frac{kg}{(m\,s)^{\frac{1}{2}}}$ and $g = 9.80665\frac{m}{s^2}$.

Problem 3:

The bar ABC is attached to the vertical rode with a horizontal pin. The assembly is free to rotate about the axis of the rod. Ignoring friction, the equations of motion for the system are:

$$\ddot{\theta} = \dot{\phi}^2\, sin\,\theta\, cos\,\theta \qquad \ddot{\phi} = -2\dot{\theta}\dot{\phi}\cot\theta$$

The system has initial conditions as follows:



$$\theta(0) = \frac{\pi}{12}rad$$

$$\dot{\theta}(0) = 0$$

$$\phi(0) = 0$$

$$\dot{\phi}(0) = 20\ \frac{rad}{s}$$

Find a numerical solution for the system using the adaptive Runge-Kutta method for t=0 to t=1.5s and plot $\dot{\phi}$ as a function of time.