Exam 1, CSC 2262, Spring 2020   Print Name Kha Le

1) An artillery shell is fired from the top of a cliff of height h, with a muzzle velocity v_0 at an angle θ with respect to the horizontal, toward a target at a horizontal distance x from the bottom of the cliff. The firing angle θ that will permit the shell to hit the target is given by the equation

$$h\cos^2\theta + \frac{x}{2}\sin(2\theta) = \frac{gx^2}{2v_0^2}$$

100 A

where h = 320 m, x = 750 m, and g = 9.81 m/s^2 .

The time t that the shell is in the air, and the maximum height of the shell with respect to the ground, y_{max}, are given by

$$t = \frac{v_0\sin\theta}{g} + \sqrt{\frac{v_0^2\sin^2\theta}{g^2} + \frac{2h}{g}}$$

$$y_{max} = h + \frac{v_0^2\sin^2\theta}{2g}$$

Write a MATLAB program as follows:

1) v_0 will go from 70 m/s to 74 m/s in steps of 2 m/s .

2) For each value of v_0, call the function newton to calculate both values of θ that will enable the shell to hit the target. Then use these calculated values of θ to calculate t and ymax according to the above formulas. Scan the θ axis from 0° to 90° in steps of 1° to look for solutions for θ . Use 1e-7 as the accuracy factor. Print v_0, θ (in degrees), t, and y_{max}.

Do not write the function newton.

The output of this program should look like this:

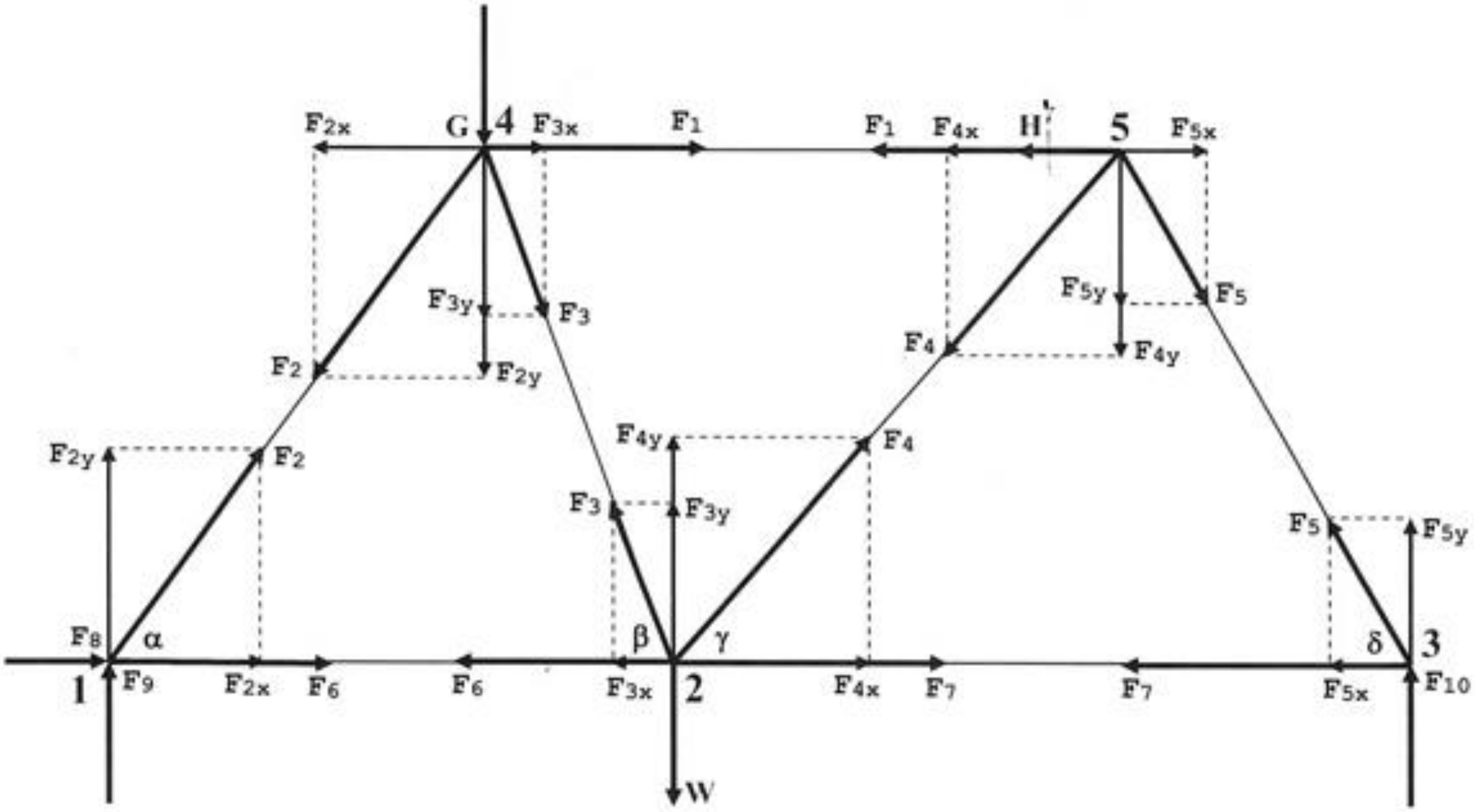
```
v0=70  theta=29.12391  t=12.26495  ymax=379.15885
v0=70  theta=37.76976  t=13.55418  ymax=413.69039

v0=72  theta=21.40677  t=11.18853  ymax=355.19817
v0=72  theta=45.48691  t=14.85819  ymax=454.35536

v0=74  theta=17.19549  t=10.60936  ymax=344.39327
v0=74  theta=49.69818  t=15.66932  ymax=482.33511
```

2)

Kha Le



In the triangular truss shown above, the forces in each strut act at the ends only and are parallel to the strut. External forces W and G act vertically at nodes 2 and 4, and external force H acts horizontally at node 5. The truss is supported by the horizontal force F_8 and vertical force F_9 at node 1 and by the vertical force F_{10} at node 3. The angles are α=47°, β=66°, γ=45°, δ=79°, and W=350, G=390, H=240.

Write a MATLAB program to calculate and print the unknown forces F_1 - F_{10} .

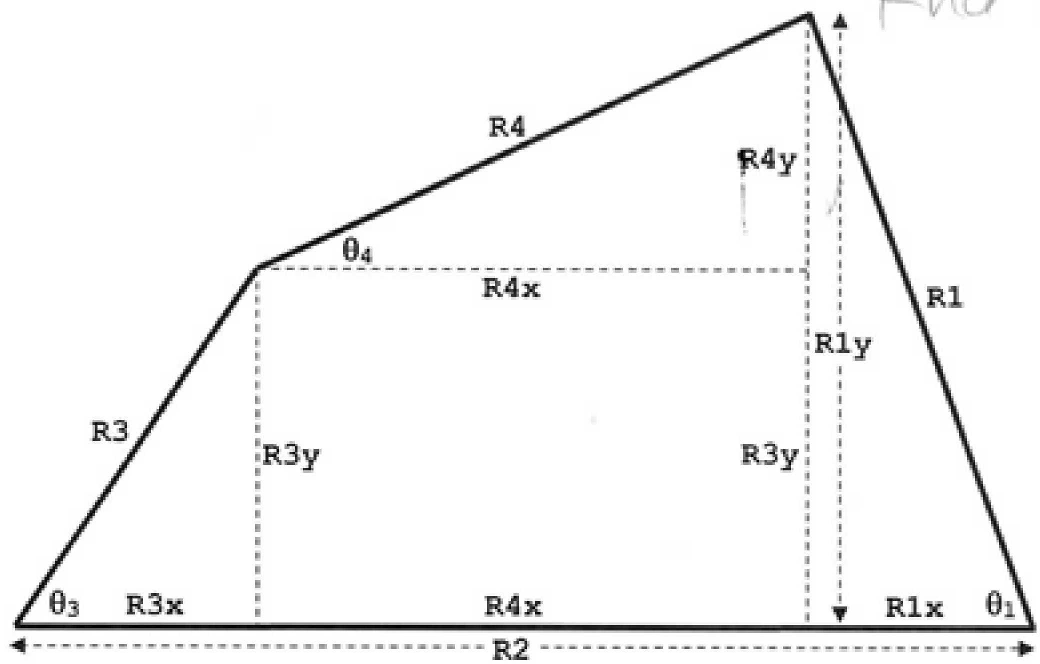
The output of this program should look like this:

```
F =

 -521.3490
 -689.7338
  125.2695
  333.1331
 -239.9696
  230.3973
   45.7884
  240.0000
  504.4394
  235.5606
```

3)

Kha Le



In the four bar linkage shown above, R1=4.15, R2=3.78, R3=2.56, R4=3.24 .

Write the MATLAB statements to do the following:

1) θ_3 will go from 85° to 805° in steps of 1° .

2) For each value of θ_3 , <u>call the function newton2</u> to calculate θ_1 and θ_4 . Use 70° and 35° as the initial guesses for θ_1 and θ_4 and 1e-7 as the accuracy factor.

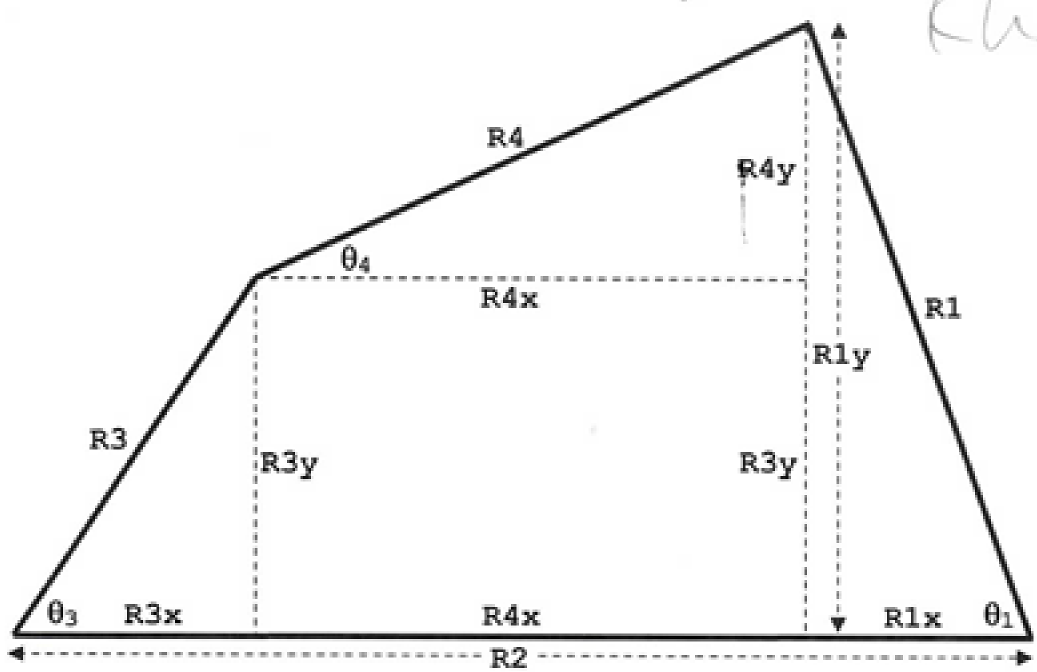
Use the variables t1, t3 and t4 for θ_1, θ_3 and θ_4 .

<u>Do not write the plot statements or the pause statements</u>.

<u>Do not write the function newton2</u>.

4)

Khole



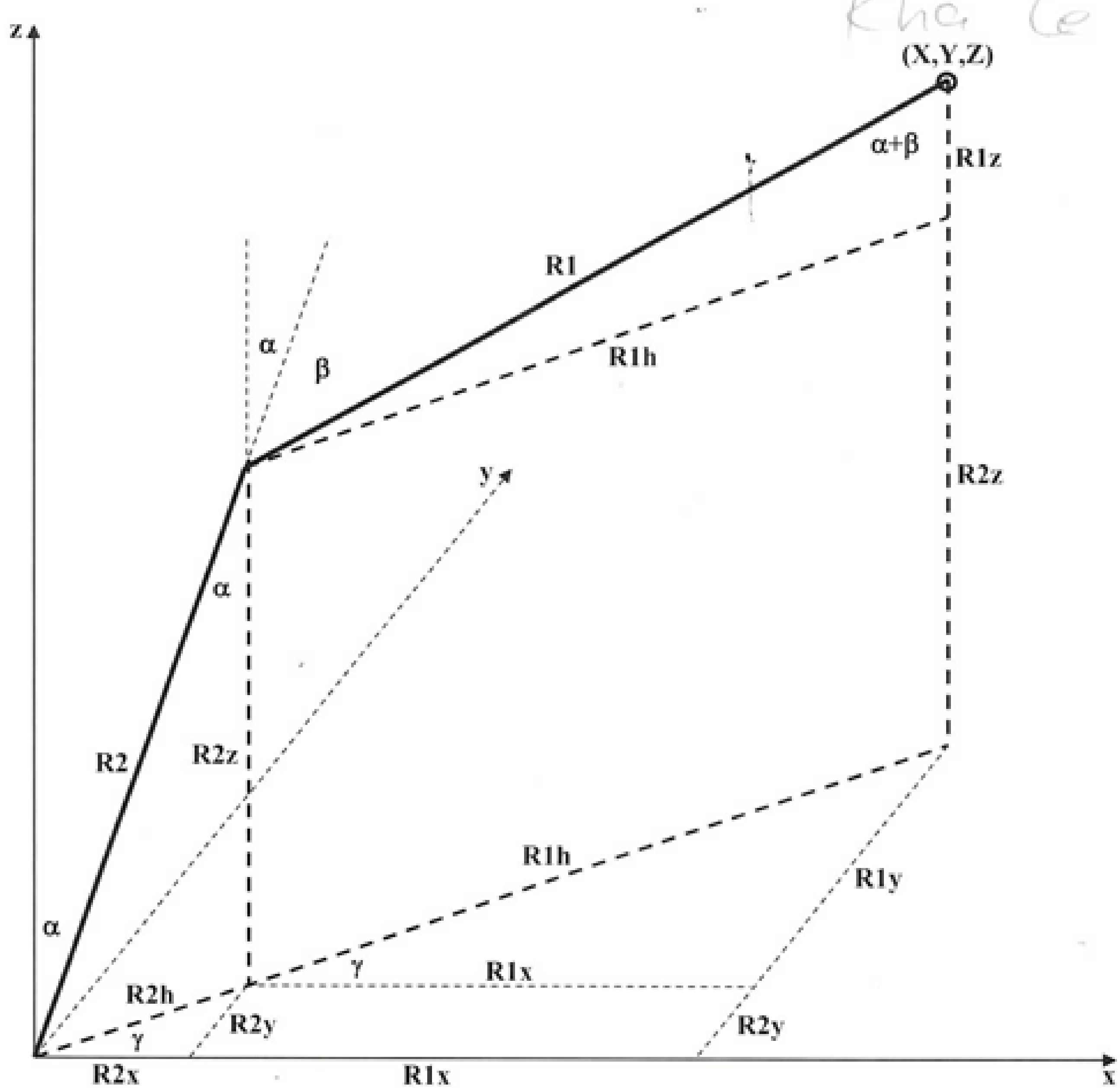
Define the arrays needed to plot the four bar linkage shown above, and write the plot statement to plot R1, R2, R3 and R4 in blue, black, red and green.

Name the arrays line1x, line1y, line2x, line2y, line3x, line3y, line4x and line4y. Use the variables t1, t3 and t4 for θ_1, θ_3 and θ_4 .

<u>Do not write any other statements for the graph except the plot statement</u>.

5)

Kha le



The robotic arm shown above consists of links R1 and R2, where R1=2.5 and R2=2.1 . R1, R2, and the z axis are all in the same plane. R2 makes an angle α with the z axis, R1 makes an angle β with the direction of R2, and the horizontal component of the arm makes an angle γ with the x axis. The arm needs to reach the point (X,Y,Z) where X=2.72 and Y=1.43 .

Write a MATLAB program as follows:

1) Z will go from 1.4 to 2.0 in steps of .3 .

2) For each value of Z, <u>call the function newton3</u> to calculate α, β and γ so that the end of the arm will be at the point (X,Y,Z). Use 30°, 60° and 20° as the initial guesses for α, β and γ and 1e-7 as the accuracy factor.
Print Z, α, β and γ.

<u>Do not write the function newton3</u>.

The output of this program should look like this:

```
Z=1.4  alpha=17.90548  beta=85.94061  gamma=27.73249
Z=1.7  alpha=16.39854  beta=80.83014  gamma=27.73249
Z=2.0  alpha=15.83656  beta=74.62852  gamma=27.73249
```

6) The differential equations for modeling the behavior of four interacting species are:

Khale

$$\frac{dx}{dt} + Bxy = x - x^2$$

$$\frac{dy}{dt} + Ay - Dxy = -yz$$

$$\frac{dz}{dt} + Cz = yz$$

$$\frac{dw}{dt} + Ew - Fwyz - Gwxy = -w^2$$

where A = .004, B = .03, C = .0017, D = .0012, E = .0038, F = .00076, G = .00045, and x, y, z and w are the populations of the four species.

Write a MATLAB program as follows:

1) t will go from 0 to 30 sec in steps of .001 sec .

2) Calculate x, y, z and w for each value of t. Use 1e-7 as the Accuracy factors and 800, 400, 500 and 300 as the initial values of x, y, z and w.

3) Plot x, y, z and w versus t using the colors red, blue, green and magenta. Just write the plot statement. Do not write any other statements for the graph.

This program has a function defined in a separate MATLAB file. Name this function prog6f.

Write both the main program and the function.

Kha Le

7) Find the inverse of the following 3x3 matrix:

$$A = \begin{bmatrix} 2 & 1 & 1 \\ 3 & 2 & 1 \\ 2 & 1 & 2 \end{bmatrix}$$

Show your work (show the steps).