Graduate Preliminary Study | ***Zagazig university***
Engineering Computational Methods (ENG 502) | ***Faculty of Engineering***
Full Marks: 70 M Jan. 2018 | ***Physics& Eng. Mathematics Dept.***

For Civil, Electrical and Mechanical Departments

1 a The axial force F_i, in each of a 12-member pin connected truss can be calculated by solving the following system of 12 equations: **7 M**

$F_2 + 7F_1 = 0,$ $F_3 - 7F_1 - 20 = 0,$ $7F_1 + F_4 + 62 = 0,$
$F_2 - 6F_5 + F_6 = 0,$ $F_4 + 7F_5 - 60 = 0,$ $F_3 - 6F_5 + F_7 = 0,$
$8F_5 + F_8 = 0,$ $F_6 + 9F_9 + F_{10} = 0,$ $F_8 - 5F_9 - 80 = 0,$
$F_7 - 9F_9 + F_{11} = 0,$ $3F_9 + F_{12} - 24 = 0,$ $F_{10} - 7F_{12} = 0$

Write the MATLAB commends that calculate the axial forces F_i, $i = 1, 2, \cdots, 12$.

b The location $\bar{x}$ of the centroid of an arc of a circle is given by **7 M**

$$\bar{x} = \frac{r sin\alpha}{\alpha}$$

Determine the angle α for which $\bar{x} = \frac{3r}{4}$. Write the MATLAB code to calculate α.

c Solve the system of nonlinear equations **7 M**

$$0.5x^2 + lny = 1.3$$
$$lnx + 0.5y^2 = 0.825$$

Using the initial values $x = 2$, $y = 0.6$, two steps are required.

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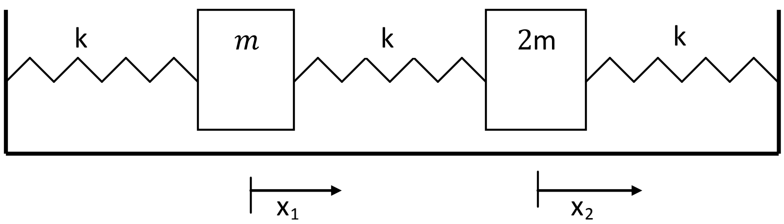
2 a Given the system of linear differential equations **7 M**

$$y_1{}' = y_1 - 3y_2$$
$$y_2{}' = y_2 - 3y_1$$

Put the system in the matrix form $y' = Ay$. Determine the eigenvalues and eigenvectors of A then solve the system.

b Consider the spring-mass system as shown in the figure. **7 M**
Assume the two mass-displacements to be denoted by x_1, x_2 and let each spring has the same spring constant $k = 20$ and let $m = 10$, then:

i) Applying equilibrium equations, write the equations of motion for free vibration.
ii) Apply $x_i = A_i \sin(\omega t)$ to formulate the problem as an eigenvalue problem.
iii) Write a MATLAB program to calculate the eigenvalues and eigenvectors of the model.



3 a Given the initial value problem $y' = -1.2y + 7e^{-0.3\,x}$, $y(0) = 3$. **10 M**

i) Solve the problem by Runge Kutta method using $h = 0.5$ from $x = 0$ to $x = 1$.

ii) Write the MATLAB commands that uses the given function 'odeRK4' to solve the problem with h=0.1 from $x = 0$ to $x = 5$

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function [x, y] = odeRK4(ODE,a,b,h,yini)
x(1) = a; y(1)= yini;
n = (b - a)/h;
for i = 1:n
x(i +1) = x(i) + h;
K1 = ODE(x(i) ,y(i));
xhalf = x(i) + h/2;          yK1 = y(i) + K1*h/2;
K2 = ODE(xhalf,yK1);  yK2 = y(i) + K2*h/2;
K3= ODE(xhalf,yK2);  yK3= y(i) + K3*h;
K4= ODE(x(i + 1),yK3);

y(i+1) =y (i) + (K1+ 2*K2 + 2*K3 + K4) *h/6;
end
```

b Solve $\frac{d^2y}{dx^2} + 2\frac{dy}{dx} + 2y = 0$, $y(0) = -1$, $y'(0) = 0.2$, from $x = 0$ to $x = 1.0$. **7 M**

Take $h = 0.5$.

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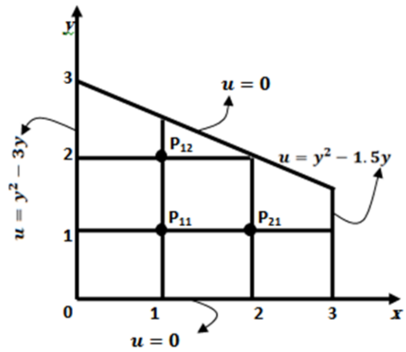
4 a Use the finite difference method to solve Laplace equation $\nabla^2 u = 0$, in the shown region using the given grid, with h=1 in x and y directions, and the given boundary values. **10 M**



b Given the diffusion equation $u_{xx} = u_t$, find the temperature distribution $u(x, t)$ in a thin tube 20 cm long with $u(0, t) = 0$, $u(20, t) = 10$ and initial condition $u(x, 0) = 2$ (take $h = 4$ cm). (Three steps are required.) **8 M**

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