KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY
Department of Mechanical Engineering
B. Sc. Engineering 4th year 2nd Term (Backlog) Examination, 2014
ME 4019
(Aerodynamics)

Time: 3 Hours. Total Marks: 210

N.B. i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Necessary Charts may be supplied on request.
iv) Assume reasonable data if any missing.

SECTION - A

1(a) Define vortex and circulation. Also, derive the equation of velocity potential and stream function of a vortex flow. 15

1(b) Write short notes on Rankine half flow and give expression of its velocity potential as well. 15

(c) Differentiate between Aerodynamics and Gas dynamics. 05

2(a) Define pressure drag, skin friction drag, induced drag and geometric altitude. 12

2(b) Define flow separation and write its consequences on an airfoil. 12

2(c) An infinite wing with chord length 1.5 m has been tested in a low speed subsonic wind tunnel. The wing has an NACA 4415 airfoil section and angle of attack is 6^o. The free stream velocity of air is 45 m/sec. Determine the lift, drag and moment about quarter chord per unit span if the air temperature is 282.31K and coefficient of viscosity for air is 1.5×10^{-5} kg/m.s. 11

3(a) Why Elaps are used in aircraft? Obtain an expression for stall velocity (V_{stall}). 17

3(b) Consider two different points A and B on the surface of an airplane wing flying at 80 m/sec. The pressure coefficient and flow velocity at point A are -1.5 and 110 m/sec respectively. The pressure coefficient at point B is -0.8. Assuming incompressible flow, calculate the flow velocity at point B. 18

4(a) Derive Kutta-Joukowski in case of lift of an airfoil. 18

4(b) State Kelvin's circulation theorem. Hence prove that circulation around the airfoil is equal and opposite to the circulation around the starting vortex. 17

SECTION – B

5(a) Show that quarter cord point of an airfoil is both the centre of pressure and aerodynamic centreif$\gamma(\theta) = 2\alpha\, V_\alpha \left(\frac{1+\cos\theta}{\sin\theta}\right)$, where symbols have their usual meanings. 18

5(b) Calculate total circulation of a cambered airfoil and also determine coefficient of lift if local circulation distribution is $\gamma(\theta) = 2V_\alpha \left(A_o \frac{1+\cos\theta}{\sin\theta} + \sum_{n=1}^{\infty} A_n \sin n\theta\right)$. 17

6(a) Define profile drag and Helmholtz's theorem. Show that $V = \frac{\Gamma}{4\pi h}$ in the case of semi-infinite vortex filament, where the symbols have their usual meanings. 15

6(b) Derive the fundamental equation of Prandtl lifting line theory. 20

7(a) Prove that $\alpha_i = \frac{C_L}{\pi AR}$ for an elliptical lift distribution. 17

7(b) Obtain $C_p = -\frac{2\hat{U}}{V_\alpha}$ by using linearized perturbation velocity potential equation's consistency. 18

8(a) Define drag divergence Mach number and explain Area rule with neat sketch. 15

8(b) Obtain an expression for Newton sine squared law. 20

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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 4th year Backlog Examination, 2014

ME 4021

(Aircraft Flight Dynamics)

Time: 3 Hours. Total Marks: 210

N.B. i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Necessary Charts may be supplied on request.
iv) Assume reasonable data if any missing.

SECTION - A

1(a) Explain with neat sketch the different wing shapes that are used in modern airplane and discuss the reasons behind this differences. 15

1(b) Classify the basic structural components of a modern aircraft and explain them with neat sketches. 15

1(c) Write notes on stall of an airfoil. 05

2(a) State and explain the Daniel Bernoulli's principle. 10

2(b) Explain the working principle of an after burner turbojet engine. 15

2(c) Deduce the expression for rate of climb in terms of excess power. 10

3(a) Write short notes on (i) pressure coefficient, (ii) critical pressure coefficient. 10

3(b) How can shock wave be minimized? 10

3(c) Derive the formula for induced drag coefficient. 15

4(a) How can flap increase lift coefficient? State with neat sketch other high lift generating devices. 10

4(b) Write down the working principle of turbojet engine. What are the advantages of using after burner in turbojet engine. 13

4(c) How does rocket engine work? What is rocket propellant? Classify them. 12

SECTION – B

5(a) What basic information can we get from drag polar graph? Show zero lift drag is exactly equal to the drag due to lift for level and steady flight. 15

5(b) Derive the Breguet formula for propeller driven airplane and hence show that endurance depends on altitude whereas range is independent of altitude. 20

6(a) What factors do affect the lift off distance of an airplane? 15

6(b) Deduce the expression of turn rate for pull up and pull down turning. How turn rate and turn radius affect the maneuvering performance. 20

7(a) Define static ability and dynamic stability. What are the necessary criteria for longitudinal balance and static stability? Explain them. 10

7(b) What is meant by aerodynamic centre and absolute angle of attack? 10

7(c) Deduce the expression for total pitching moment about the centre of gravity. 15

8(a) Derive the expression for specific impulse I_{sp} in terms of pressure and temperature of initial and exit conditions. 20

8(b) Consider a thin supersonic airfoil with chord length c = 1.67m in Mach No. 2.8 free stream at standard altitude of 6590m. The airfoil has an angle of attack of 6°. Calculate - 15

(i) Lift and wave drag per unit span;

(ii) Lift and wave drag coefficient.

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KHULNA UNIVERSITY OF ENGINEERING & TECHNOLOGY

Department of Mechanical Engineering

B. Sc. Engineering 4th Year 2nd Term (Backlog) Examination, 2014

ME 4085

(Servo Mechanism & Control Engineering)

Time: 3 Hours Total Marks: 210

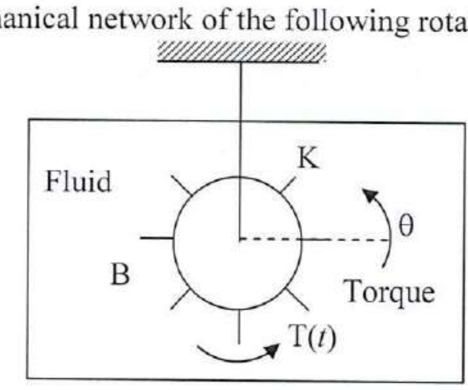
N.B.: i) Answer any THREE questions from each section in separate scripts.
ii) Figures in the right margin indicate full marks.
iii) Assume reasonable data if any missing.

SECTION-A

1(a) Explain how a dc generator act as a single stage rotating power amplifier. 12

1(b) Show that an ac servomotor provides stable open loop operation. What are the assumptions underlying the analysis? 11

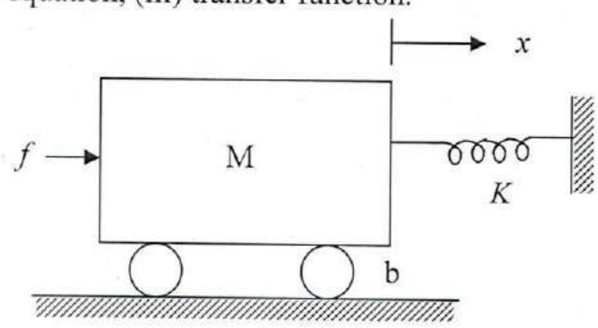
1(c) Draw the mechanical network of the following rotational system. 12



The system has a mass with moment of inertia, J immersed in the field.

2(a) State different nodes and paths in a signal flow graph. 08

2(b) Consider the system as shown, represent the system using (i) differential equation, (ii) state equation, (iii) transfer function. 12



2(c) For the following equations, draw the signal flow graph and find the overall transmittance. 15

$x_2 = a_{12}x_1 + a_{32}x_3 + a_{42}x_4 + a_{52}x_5$

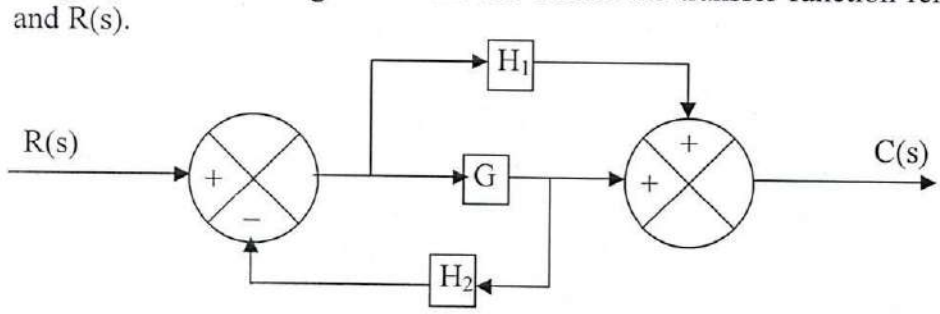
$x_3 = a_{23}x_2$

$x_4 = a_{34}x_3 + a_{44}x_4$

$x_5 = a_{35}x_3 + a_{45}x_4$

where x_1 is input and x_5 is output variable.

3(a) Simplify the block diagram as shown. Obtain the transfer function relating C(s) and R(s). 10



3(b) The open loop transfer function of a unity feedback system is $G(s) = \frac{K}{s\,(1+4s)\,(1+2.5s)}$. Find the restriction on 'K' so that the closed loop is stable. 15

3(c) Use Routhian array, determine the number of roots in the right half of s-plane for the following characteristic equation. 10

$$s^4 + s^3 + 2s^2 + 9s + 5 = 0$$

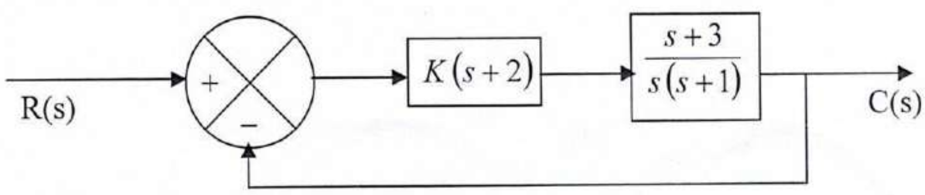
4(a For a second order system with a unit step input and having zero initial conditions, find the time at which peak overshoot occurs and the value of peak overshoot. 15

4(b) The performance equation of a dc motor is given by $A_2D^2w_m + A_1Dw_m + A_ow_m = e_a$ where w_m is the response and e_a is input. Find the steady state response when a dc voltage is applied as input. 10

4(c) Deduce the expressions for step, ramp and parabolic error coefficients for type 1 system. 10

SECTION-B

5(a) Define break-in and break-away points of a root locus. Sketch the root locus for the system given below. 20



5(b) What is the effect of adding poles and zeros to transfer function on the root locus and the system? 08

5(c) Show that root locus branches start at open loop poles and end at open loop zeros. 07

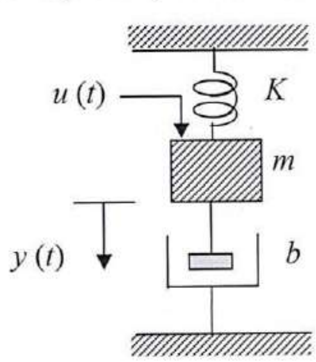
6(a) Define gain and phase margins. Explain their significance in defining the stability of a system. 10

6(b) Draw the bode diagram of the following system and comment on the stability of the system. 17

$$G(J\omega) = \frac{5\,(1+J0.1\omega)}{j\omega\,(1+J0.5\omega)\left\{1+J0.6\left(\frac{\omega}{50}\right)+\left(J\frac{\omega}{50}\right)^2\right\}}$$

6(c) How can you determine transfer function of an unknown system in the laboratory? 08

7(a) Write down the state-space representation of the following system. 10



$u(t)$ = external force

$y(t)$ = displacement

7(b) Define controllability, observability. Determine whether the system is (i) state controllable, (ii) controllable, and (iii) output controllable. 15

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ -2 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u, \qquad y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

7(c) Describe the operating principle of an on-off controller. What are the limitations of this controller for highly dynamic system? Why is differential gap introduced in this controller? 10

8(a) Briefly explain P, PI, PD and PID controllers. 10

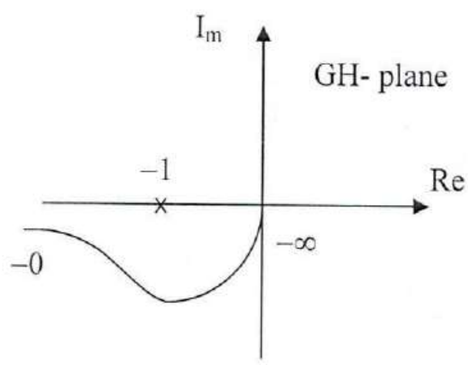
8(b) What are the role of eigen values in control system engineering? Calculate the following matrix: 13

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix}$$

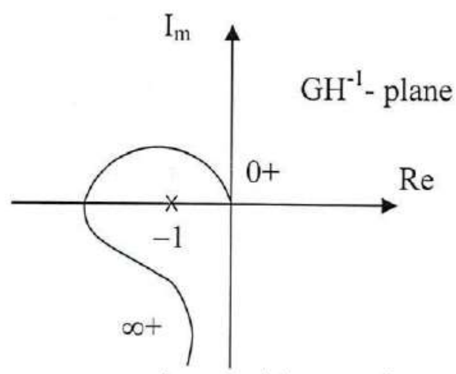
Show that the eigen values of a system remain the same after linear transformation.

8(c) Explain Nichols chart. 06

8(d) Complete the following polar plots and comment on the stability of the systems using Nyquist criterion. 06



$$GH = \frac{K}{s^2 (Ts + 1)}$$



$$[GH]^{-1} = \frac{s(1 + T_1 s)(1 + T_2 s)}{K}$$