Alexandria University
Faculty of Engineering
Mechanical Engineering Department

جامعة الإسكندرية
كلية الهندسة
قسم الهندسة الميكانيكية

January 2016 | يناير ٢٠١٦

Internal Combustion Engines | محركات احتراق داخلى

Time allowed: 3 hours | الزمن : ثلاث ساعات

STUDENTS ARE ALLOWED TO USE COMBUSTION TABLES & CHARTS

Examiners : ***Prof. Dr. M. M. El-Kassaby, Prof. Dr. M. Noor, Dr. Amr Hassan, Dr. Ahmed el-Werdany***

Answer All Questions:

QUESTION ONE (18 Points)

A **rigid** vessel initially contains 2 kmol of carbon and 2 kmol of oxygen at 25°C, 200 kPa. Combustion occurs, and the resulting products consist of 1 kmol of carbon dioxide, 1 kmol of carbon monoxide, and excess oxygen at a temperature of 1000 K.

Determine:-

1-The final pressure in the vessel and the heat transfer from the vessel during the process.

2- The irreversibility for the process

3-How do you explain the presence of CO in the product?

$$I = \sum n_e T_o S_e - \sum n_i T_o S_i - Q_{c.v} \qquad \overline{S_i^*} = \overline{S^\circ{}_{T_i}} - \overline{R}\ln\frac{P}{P_o} - \overline{R}\ln y_i$$

QUESTION TWO (5 Points)

Air (assumed to be 79% nitrogen and 21% oxygen) is heated in an SSSF process at a constant pressure of 100 kPa, and some NO is formed. At what temperature will the **mole fraction** of NO be 0.001?

QUESTION THREE (23 Points)

(a) Explain, **briefly**, how the Electronic Control Unit (**ECU**) calculates the precise value of the mass flow rate of air..

(b) Explain, **briefly**, why the oxygen sensor (lambda sensor) gives erroneous data during cold starting.

(c) Explain, **briefly**, how the Electronic Control Unit (**ECU**) delivers the injected fuel in proportion of the time during which the injector is open.

(d) Explain, **briefly**, how the Electronic Control Unit (**ECU**) manages the operation of the Electronic Throttle Control (**ETC**) in **Motronic** Systems.

(e) A one-liter, two-stroke engine runs at 3600 rpm. The scavenging efficiency is 0.6. Using the **Perfect Displacement Assumption, *calculate*** :

- the mass flow rate of fresh charge delivered (kg/ min)

Then use the Perfect Mixing Model ($\eta_{sc} = 1 - e^{-\Lambda}$) to find the delivery ratio.

Assume reference conditions $P_o = 100$ kPa $T_o = 298$ K

(f) Prove that the residual-gas mass fraction x_r in a spark ignition engine is given by:

$$X_r = v_2 / v_5$$

where v_2 and v_5 are the specific volumes of the cylinder contents at the end of compression and the end of blowdown, respectively.

QUESTION FOUR (23 Points)

Part (A) Explain the following (12 Points) :

1. Using very high injection pressure in indirect injection diesel engines is not recommended
2. The exhaust gas recirculation technique can reduce the combustion temperature
3. The cold start period of indirect injection diesel engines is usually longer compared to direct injection diesel engines
4. Indirect injection diesel engines can operate with higher maximum speeds than direct injection diesel engines
5. Diesel engine knock intensity can decrease with increasing engine compression ratio
6. The injection pressure is lower during engine idling operation compared to the full load condition in the fuel distributor pump injection system

Part (B) Answer the following (11Points) :

1. Describe how the fuel to air ratio changes throughout the fuel spray exiting from the injector orifice
2. Define the spray tip penetration and show how its value can affect diesel engine emissions
3. How can the diesel injection rate affect diesel engine knock? Describe how the injection rate can be controlled in both the unit injector and the common rail injection systems
4. Why should the closure time of a mechanical injector be very short? How can that be achieved?
5. How can the injection timing be controlled in an electronically controlled distributor fuel pump?

QUESTION FIVE (23 Points)

1. Draw schematic temperature profiles through the combustion chamber to the coolant at intake stroke and just after combustion showing the difference between the two profiles? **(2 pt)**
2. Explain the effect of the equivalence ratio on the heat transfer loss as a percentage of fuel energy for three different burning durations. **(2 pt)**
3. What are the main functions and components of the pressurized lubrication system? **(2 pt)**
4. The well-designed oil filter must have two valves. Mention them and their functions. **(2 pt)**
5. What is meant by multi-grade lubrication oil? Compare between the following four SAE oil classifications: SAE 10W, SAE 20, SAE 50 and SAE 10W/50. **(3 pt)**
6. How are the blow-by gases formed ? Explain the concept to get rid of them. **(2 pt)**
7. Describe what is meant by smog and how it is formed. **(2 pt)**
8. Explain the effect of equivalence ratio on HC, CO and NOx emissions from SI engines. **(2 pt)**
9. What is meant by light-off temperature of catalytic converter? Explain the effect of temperature on catalyst conversion efficiency of HC and CO. **(2 pt)**
10. Explain the effects of the excess air ratio on catalyst conversion efficiency of NOx, HC and CO in 3-way catalytic converter. **(2 pt)**
11. What is the difference between using exhaust gas or air as diluent on NOx emissions? **(2 pt)**

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ME 341: Mechanical Design - 2
THIRD YEAR Final Exam January 2016
Time: Three Hours

ME 341 تصميم ميكانيكي – ٢
السنة الثالثة – إمتحان نهاية الفصل الدراسى يناير ٢٠١٦
الزمن: ثلاث ساعات

NOTES: - Answer all questions and assume any missing data
- Use sketches whenever suitable to illustrate your answer

PART : ONE

Question # 1 (25 points)

a. Draw a sketch representing a single riveted double strap butt joint *(3 points)*

b. State 2 advantages and 2 disadvantages of using adhesive joints *(2 points)*

c. State 2 types of destructive and 2 types of nondestructive tests of weld joints *(2 points)*

d. A rectangular steel cantilever bar is secured by four bolts as shown in figure 1. Select a suitable 12.9 class bolt size. The 12.9 class proof strength is 1120 MPa and the factor of safety required for bolts is 4. *(10 points)*

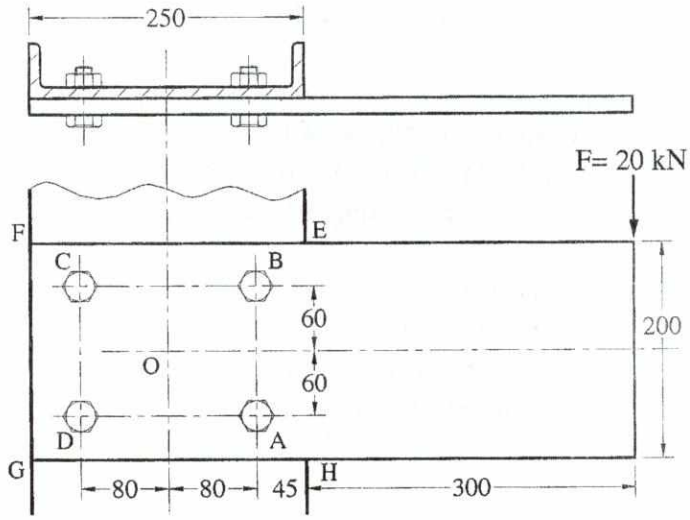


Figure 1

e. If the bolts are replaced by a 2 horizontal lines welds EF & GH select a suitable size of weld. Take the ultimate strength of weld material is 420 MPa and the required factor of safety is 4. *(8 points)*

Question # 2 (25 marks)

a. State the 4 types of belts *(2 points)*

b. How to minimize the chordal action effect in chains *(2 points)*

c. What is the classification wire ropes according to usage (state the classification only) *(2 points)*

d. The shaft shown in figure 2 transmits power from a 5 kW electric motor, through a leather V-belt to a fan. The motor speed is 1200 r.p.m. The motor pulley is 200 mm diameter and the shaft pulley 2 has 400 mm diameter. Select a suitable V-belt type and belt length. *(8 points)*

e. If the belt drive is replaced by a chain drive having 25 teeth in the small sprocket, select a suitable Type A chain size and determine the diameters of the sprockets and chain length *(8 points)*

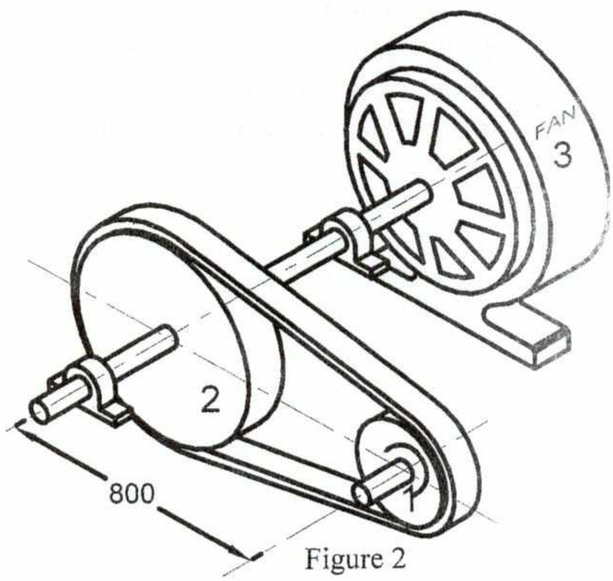


Figure 2

f. What is the number of turns of a rope on a capstan needed for a person with 200 N pulling force to move a ship with a 200 kN resistance when the friction coefficient is 0.3 *(3 points)*

Good Luck *Dr. Ibrahim El Fahham* *Dr. Mustafa Elhadary*

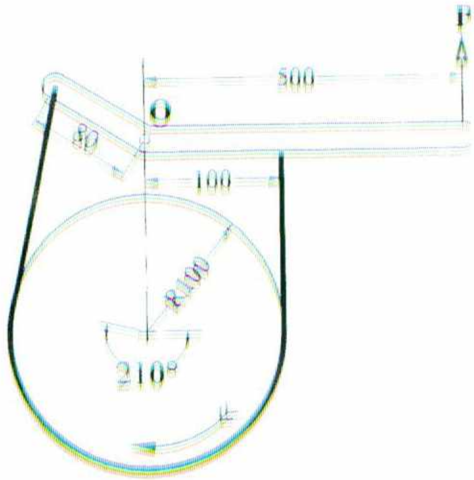
PART: TWO

Question # 3: (15 marks)

a. Derive an expression to find the actuating force and torque required for a disc clutch assuming uniform wear.

b. A jaw clutch has three jaws. The outer and inner diameters of the jaw are 250 mm and 200 mm respectively. The axial height of the jaws is 30 mm. The clutch is made of steel having Sy= 420 MPa. Determine the maximum power that the clutch can transmit at 600 rpm. Use a factor of safety of 1.5

Question # 4: (15 marks)



a. Derive an expression to find the braking torque for external shoe brake.

b. A hoisting elevator engine is equipped with the band Brake shown in the figure. The force F is actuated electrically to maintain the band at a maximum contact pressure of 300 kPa. If the maximum braking torque needed is 250 Nm and the friction coefficient is 0.3,

Determine:

I. The applied force F.

II. The band width and thickness if the maximum tensile stress in the band is 2.5 MPa.

Question # 5: (15 marks)

a. State the steps required for the design of the power screw.

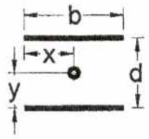
b. The cutter of a broaching machine is pulled by square threaded screw of 70mm external diameter and 12mm pitch. The operating nut is 30mm in height. The collar takes the axial load of 20kN on a flat surface of 50mm and 90mm internal and external diameters respectively. If the coefficient of friction is 0.12 for all contact surfaces on the nut and the collar, determine the power required to rotate the power screw when the cutting speed is 3m/min. Also, find the efficiency of the screw, maximum shear stress of the screw and the bearing stress on the threads.

$$T = W\left[r_m\left(\frac{L + \pi f d_m \sec\alpha}{\pi d_m - f L \sec\alpha}\right) + f_c\, r_c\right]$$

Stresses on bolts and welding

$\sigma_t = \frac{F}{A}$, $\tau_{direct} = \frac{F}{A}$, $\sigma_{bending} = \frac{M\,y}{I}$, $\tau_{torsion} = \frac{T\,r}{J}$, $\sigma_{max} = \left(\frac{\sigma}{2}\right)^2 + \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$

$\tau_{max} = \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$, $F_{sh} = \sqrt{F_s^{\,2} + F_p^{\,2} + 2\,F_s\,.\,F_p.\cos\theta}$, $\tau_{max} = \sqrt{\tau_s^{\,2} + \tau_p^{\,2} + 2\,\tau_s\,.\,\tau_p.\cos\theta}$

	$A = 1.414\,h\,b$	$x = \frac{b}{2}$, $y = \frac{d}{2}$	$i = \frac{b\,d^2}{2}$	$j = \frac{b\,(3d^2 + b^2)}{6}$

Belts:

$\frac{F_1 - F_c}{F_2 - F_c} = e^{\mu\theta}$, $\sigma_c = \rho V^2$, $\theta = 180 - 2 \times \sin^{-1}\frac{d_2 - d_1}{2C}$

V Belts: Power $= (\sigma_{all} - \sigma_c)\,.\,n\,.\,A\,.\,V\,.\frac{e^{\mu e\theta}-1}{e^{\mu_e \theta}}$, $\mu_e = \frac{\mu}{\sin^{\alpha}/_2}$ $L = 2\,C + \pi\frac{(d_2+d_1)}{2} + \frac{(d_2-d_1)^2}{4\,C}$

Coefficient of Friction of leather belt on Cast iron drum = 0.35 leather belt density = 1000 kg/m^3

For leather belt σ_{all} =2.5 MPa V Belt angle = 40°

Section	A	B	C	D	E
Nominal Cross section Area (mm^2)	80	140	230	475	680

Wire Ropes

$F_t = \left(\frac{W}{nr} + w.l\right)\left(1+\frac{a}{g}\right)$ $\frac{F_1}{F_2} \le e^{\mu\theta}$ $A_m = 0.38\,d^2$ $F_u = f_s\,F_t + F_b$

$F_b = \frac{E_r\,.\,dw.\,Am}{D}$ $Su = \frac{2000\,Ft}{d\,D}$

Chains Selection

Design Power = Application Power × K_s Corrected Rated Power = Rated Power × K_1 × K_2

$L = 2C + \frac{(N_2 + N_1)\;p}{2} + \frac{(N_2 - N_1)^2\;p^2}{4\,\pi^2\;C}$ $D = \frac{p}{\sin\,(180\,/\,N)}$

Driving machinery	Driving source		
	Internal combustion engine with hydraulic drive	Electric motor or turbine	Internal combustion engine with mechanical drive
Smooth	1.00	1.00	1.20
Moderated shock	1.20	1.30	1.40
Heavy shock	1.40	1.50	1.70

N	K_1	N	K_1	N	K_1	N	K_1
11	0.53	17	1.00	23	1.35	35	1.95
12	0.62	18	1.05	24	1.41	40	2.15
13	0.70	19	1.11	25	1.46	45	2.37
14	0.78	20	1.18	26	1.57	50	2.51
15	0.85	21	1.26	27	1.68	55	2.66
16	0.92	22	1.29	28	1.77	60	2.80

Number of strands	K_2
1	1.0
2	1.7
3	2.5
4	3.3

Dimensions of single strand American standard Roller chain (ISO Type A)

Chain Size	Pitch, mm	Width, mm	Breaking load, kN	Mass Kg/m	Roller diameter mm	Strand spacing mm
35	9.52	4.78	10.2	0.33	5.08	10.13
40	12.70	7.92	17.2	0.61	7.92	14.38
50	15.88	9.53	28.3	0.98	10.16	18.11
60	19.5	12.70	38.5	1.59	11.91	22.78
80	25.40	15.88	65.8	2.56	15.88	29.29
100	31.75	19.05	108.9	3.78	19.05	35.76
120	38.10	25.40	154.2	5.82	22.23	45.44
140	44.45	25.40	208.7	7.62	25.40	48.78
160	50.80	31.75	263.1	9.88	28.58	58.55
200	63.50	38.10	430.9	15.91	29.67	71.55

Power ratting for single strand roller chain based on A 17- Tooth Driving Wheel (kW)

Pinion speed rev/min	ISO type A medium pitch					Pinion speed rev/min	ISO type A large pitch				
	35	40	50	60	80		100	120	140	160	200
50	0.12	0.28	3.53	0.94	2.06	25	2.24	3.75	5.81	9.08	11.88
100	0.22	0.53	0.98	1.74	4.03	50	4.29	7.15	11.18	15.65	22.37
200	0.41	0.98	1.83	3.40	7.34	100	7.96	13.42	20.57	30.42	42.05
300	0.58	1.34	2.68	4.56	11.63	200	14.31	25.05	38.47	56.36	79.63
500	0.98	2.24	4.34	7.69	16.99	300	21.47	35.79	54.57	80.52	116.31
700	1.29	2.95	5.91	10.73	23.26	400	26.84	46.53	71.57	111.84	134.20
1000	1.76	3.94	8.05	14.32	28.36	500	34.00	56.36	89.47	134.20	
1400	2.42	5.28	11.18	14.32	18.49	600	39.37	67.10	107.30		
1800	3.07	6.98	8.05	10.44		700	44.73	76.05	80.52		
2000	3.40	6.26	7.16	8.50		800	49.21	57.86			
3000	4.74					900	40.26	48.31			
4000	3.04					1000	34.00				

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January 2016

جامعة الاسكندرية
كلية الهندسة
قسم الهندسة الميكانيكية
يناير ٢٠١٦

MECHANICAL VIBRATION
Third Year
Time Allowed: 3 Hours

إهتزازات ميكانيكية
السنة الثالثة
الزمن : ٣ساعات

Answer the following questions:

QUESTION ONE (20 points):

A security camera is to be mounted on a building and will be subjected to wind loads producing an applied force of $F_o \cos \omega t$, where the largest value of F_o is measured to be 15 N. This is illustrated on Figure (1). It is desired to design a mount such that the camera will experience a maximum deflection of 0.01 m when it vibrates under this load. The wind frequency is known to be 10 Hz and camera mass is 3 Kg. The mounting bracket is made of a solid piece of aluminum, 0.02 x 0.02 m in cross section. Compute the length of the mounting bracket that will keep the vibration amplitude less than the desired 0.01 m (ignore torsional vibration and assume the initial conditions are both zero). Note that the length must be at least 0.5 m in order to have a clear view.
(I for a rectangular beam = $bh^3/12$ and E for aluminum = 7.1×10^{10} Pa)

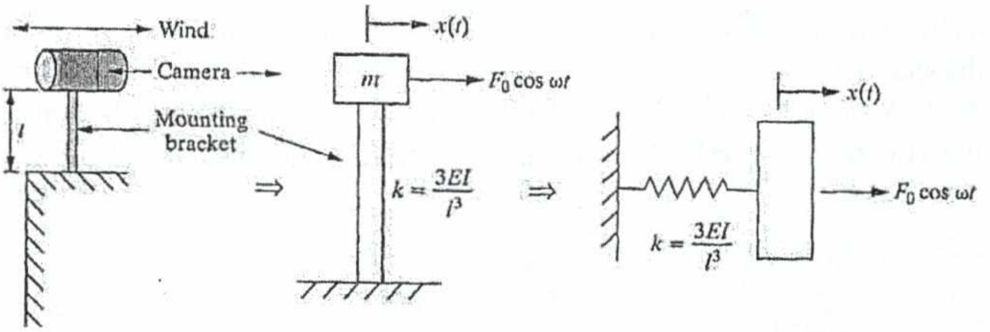


Figure (1)

QUESTION TWO (20 points):

A machine weighing 2000 N rests on a support as illustrated in Figure (2). The support deflects about 5 cm as a result of the weight of the machine. The floor under the support is somewhat flexible and moves, because of the motion of a nearby machine, harmonically near resonance (r =1) with an amplitude of 0.2 cm. Model the floor as base motion, and assume a damping ratio of $\zeta = 0.01$, and calculate the transmitted force and the amplitude of the transmitted displacement.

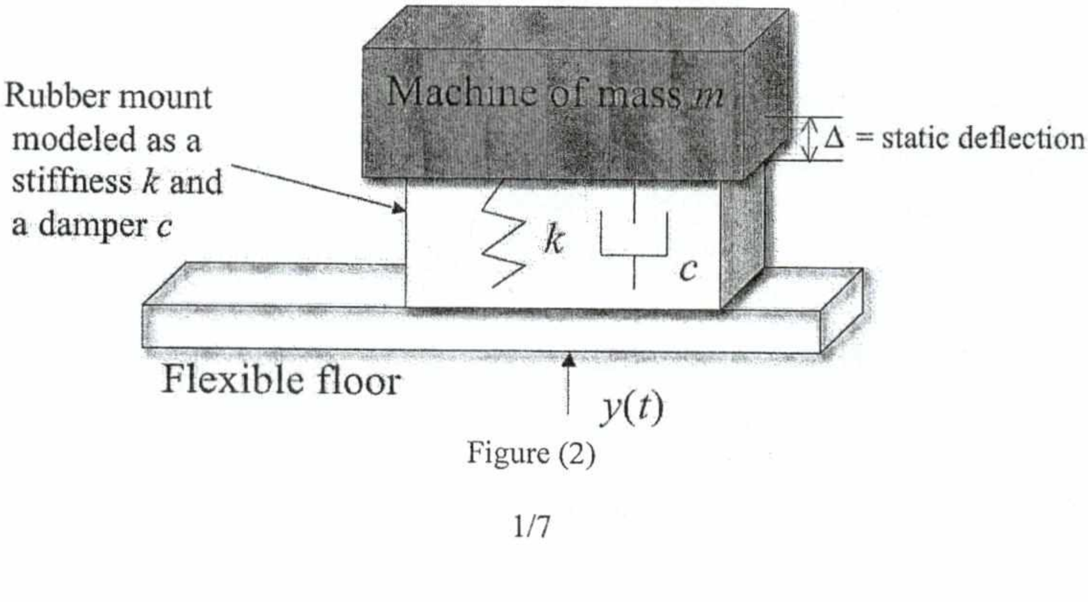


Figure (2)

QUESTION THREE (15 points):

An accelerometer is used to measure the oscillation of an airplane wing caused by the plane's engine operating at 6000 rpm. At this engine speed the wing is known, from other measurements, to experience 1.0-g acceleration. The accelerometer measures an acceleration of 10 m/s². If the accelerometer has a 0.01-kg moving mass and a damped natural frequency of 100 Hz. Use the difference between the measured and the known acceleration to calculate the damping and stiffness parameters associated with the accelerometer.

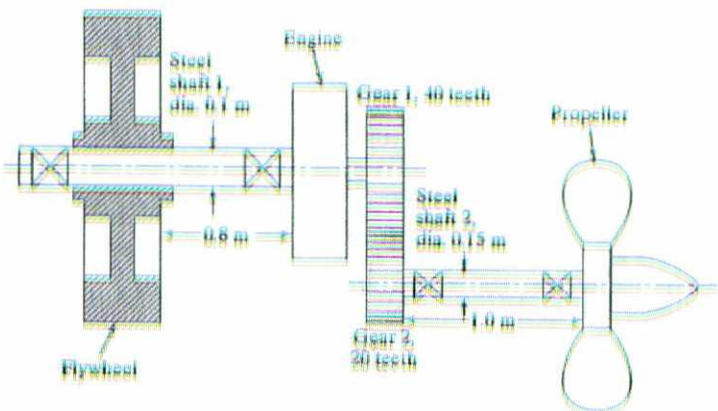
QUESTION FOUR (20 points):

The schematic diagram of a marine engine connected to a propeller through gears is shown in Figure (3-a). The system consists of the flywheel, engine, gear 1, gear 2, and the propeller. This system can be modelled as a two degree of freedom model as shown in Figure (3-b). The flywheel can be considered to be stationary (fixed), since its mass moment of inertia is very large compared to that of other rotors. The engine and the two gears can be replaced by a single rotor with a mass moment of inertia J_1 of 1850 kg-m². The propeller mass moment of inertia J_2 equals to 8000 kg-m². The shaft torsional stiffness of shaft 1 and shaft 2 can be calculated as follows

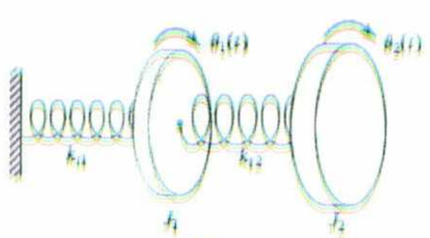
$$k_t = \frac{\pi G d^4}{L}$$

where k_t is the torsional stiffness, G the shear modulus of the shaft and equals 80 GPa, d is the shaft diameter and L is the shaft length.

Find the natural frequencies and mode shapes of the system shown in Figure (3-b) in torsional vibration. The initial conditions are θ^T=[1 0] and $\dot{\theta}^T$=[0 0]. Find the response of the system by using modal analysis.



(a)

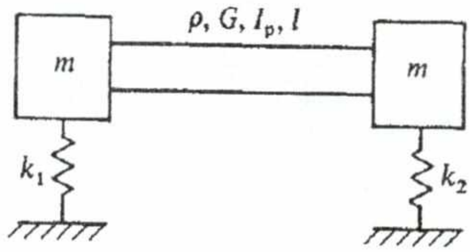


(b)

Figure (3). Marine Engine Propeller System.

QUESTION FIVE (10 points):

Obtain the coefficient matrix of the transverse vibration of the beam shown in Figure (4).



Figure(4).

QUESTION SIX (25 points):

1. What are the vibration equations used is static, dynamic and Modal Analysis in Finite Element Analysis?
2. Explain the function of a vibration sensor.
3. What are the amplitude units of vibration measurement?
4. What do non-contacting displacement sensors measure?
5. What are the frequency ranges of the vibration measures?
6. What happens when the sensor moves or rocks relative to the machine during measurement?
7. In a new machine, what controls the initial vibration levels?
8. What is the problem with taking vibration data on guards and covers?
9. What is the purpose of examining frequencies in the spectrum?
10. What is the data acquisition time for a 100 Hz spectrum using 1,600 lines?
11. What basic parameters govern resolution in an FFT analyzer?
12. What frequency is unique in gears?
13. What are the problems involved in using charts such as Dresser Clark chart for judging machine condition by using vibration measurements?
14. What is the overall peak amplitude of vibration in Figure (5)? How does this relate to the spectrum which is in RMS units?

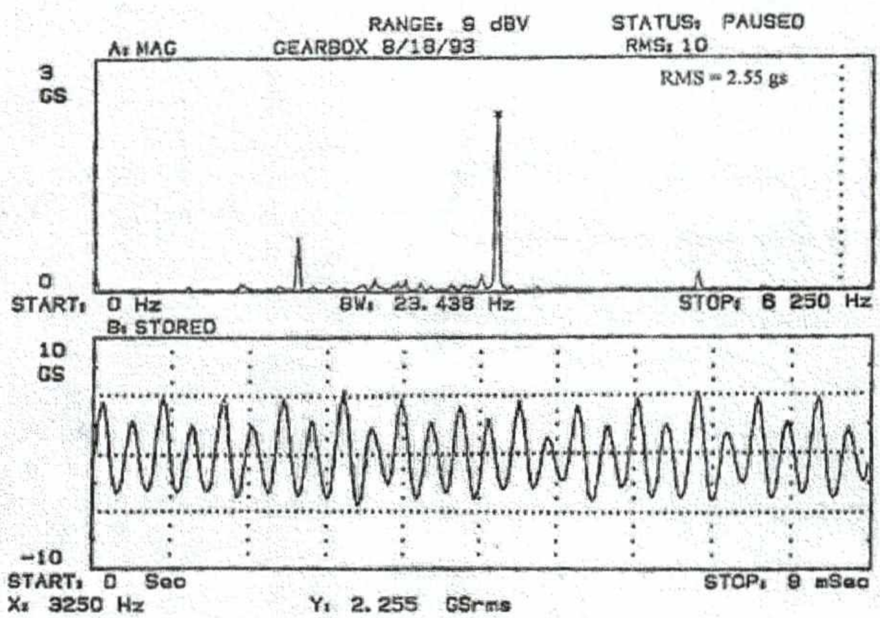


Figure (5). Acceleration Data from a 10 MW Gearbox

15. What is the fundamental frequency and amplitude of the largest spectral component shown in Figure (6)? (The amplitude units of the spectrum are RMS.)

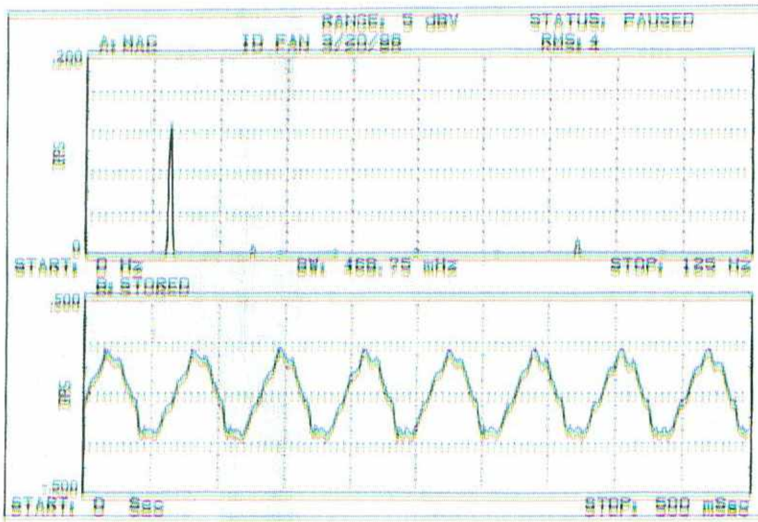


Figure (6). Spectral Data from an ID Fan

16. How does the spectrum in Figure (6) relate to the waveform below - in frequency and amplitude?
17. What machine frequencies are not directly proportional to speed?
    a. gear mesh frequencies
    b. rolling element bearing defect frequencies
    c. blade pass
    d. vane pass frequencies
    e. None of the above
18. Where measurements should be made for the machine shown in Figure (7) to assess fault and condition?

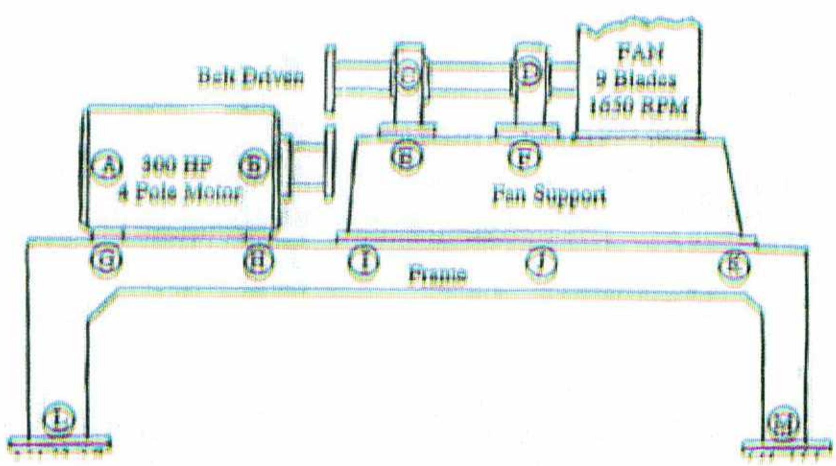


Figure (7). Motor Driven Fan

19. The data shown in Figure (8) are from a center mounted fan on rolling elements. What is the general fault indicated by the data? What are the possible mechanical causes?

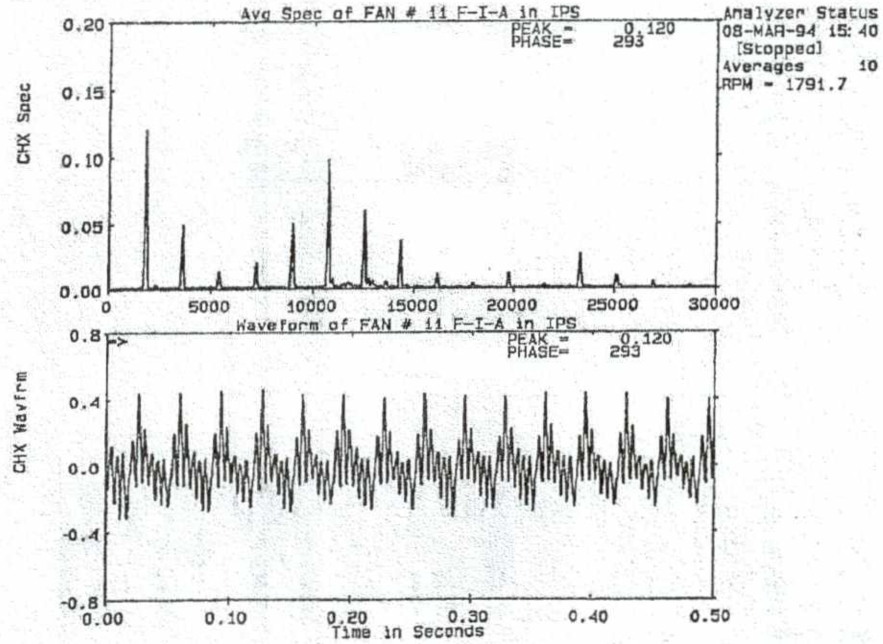
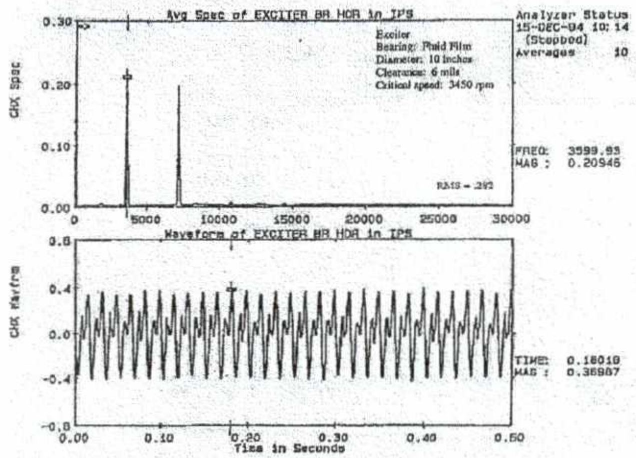
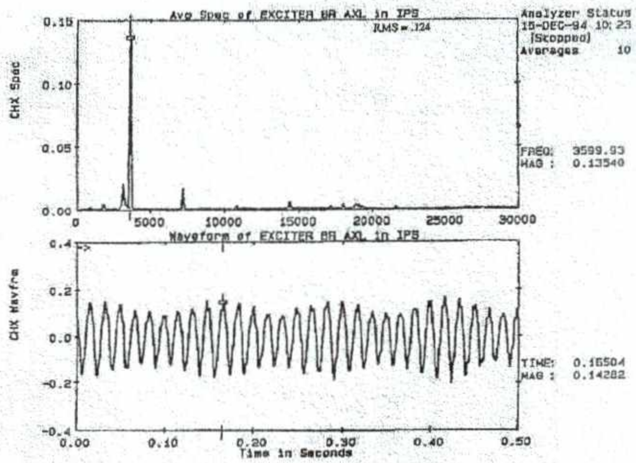


Figure (8).

20. What is the condition of the exciter whose data are shown in Figure (10)? Use the RMS values and Table 1.



Exciter Bearing Cap Vibration – Horizontal Direction



Exciter Bearing Cap Vibration – Axial Direction

Figure (10)

Table 1. Vibration Guidelines for Condition Evaluation

CONDITION	LIMITS	
	rms velocity	peak velocity
Acceptance of new or repaired equipment	0.08	0.16
Unrestricted operation - normal	0.12	0.24
Surveillance	0.12-0.28	0.24-0.7
Unsuitable for operation	0.28	0.7

$$\frac{X}{X_{st}}=\frac{1}{\sqrt{(1-r^2)^2+(2\zeta r)^2}}, \qquad \frac{MX}{me}=\frac{r^2}{\sqrt{(1-r^2)^2+(2\zeta r)^2}},$$

$$\frac{Z}{Y}=\frac{r^2}{\sqrt{(1-r^2)^2+(2\zeta r)^2}}, \qquad \frac{X}{Y}=\frac{\sqrt{1+(2\zeta r)^2}}{\sqrt{(1-r^2)^2+(2\zeta r)^2}}=TR,$$

$$F_{TR}=kX\sqrt{1+(2\zeta r)^2}, \qquad \delta=\frac{1}{n}\ln\frac{X_o}{X_n}=\frac{2\pi\zeta}{\sqrt{1-\zeta^2}},$$

$$\omega_d=\omega_n\sqrt{1-\zeta^2}, \qquad r_{peak}=\sqrt{1-2\zeta^2} \quad or \quad \frac{1}{\sqrt{1-2\zeta^2}},$$

$$\omega_{n1}^2+\omega_{n2}^2=\frac{k_1}{m_1}+\frac{k_2}{m_1}+\frac{k_2}{m_2}, \qquad \omega_{n1}^2\omega_{n2}^2=\frac{k_1}{m_1}\frac{k_2}{m_2},$$

$$\frac{X_1}{X_{st}}=\frac{\left[1-\left(\frac{\omega}{\omega_2}\right)^2\right]}{\left[\left(1+\frac{k_2}{k_1}-\left(\frac{\omega}{\omega_1}\right)^2\right)\left(1-\left(\frac{\omega}{\omega_2}\right)^2\right)\right]-\frac{k_2}{k_1}},$$

$$\frac{X_2}{X_{st}}=\frac{1}{\left[\left(1+\frac{k_2}{k_1}-\left(\frac{\omega}{\omega_1}\right)^2\right)\left(1-\left(\frac{\omega}{\omega_2}\right)^2\right)\right]-\frac{k_2}{k_1}},$$

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_i}\right)-\left(\frac{\partial T}{\partial q_i}\right)+\left(\frac{\partial U}{\partial q_i}\right)+\left(\frac{\partial D_c}{\partial \dot{q}_i}\right)=Q_i$$

$$r_i(t)=\sqrt{r_{i0}^2+\frac{\dot{r}_{i0}^2}{\omega_i^2}}\sin(\omega_i t+\tan^{-1}\frac{\omega_i r_{i0}}{\dot{r}_{i0}})$$

$$y(x,t)=(C_1\cos\beta x+C_2\sin\beta x+C_3\cosh\beta x+C_4\sinh\beta x)(A\cos\omega t+B\sin\omega t)$$

Vibration Analyst Category I Equations

g = gravitational constant, 386.1 in/s2

FOR HARMONIC MOTIONS ONLY

Velocity (in/s) $v = D(2\pi f)$ D = peak displacement, in f = frequency, cycles/s (CPS)

Acceleration $A = V(2\pi f)$ A = acceleration, in/s^2 1 g = 386.1 in/s^2

FREQUENCIES

Bearing Frequencies

$$FTF = \left(\frac{\Omega}{2}\right)\left[1 - \left(\frac{B}{P}\right)\cos CA\right]$$

$$BPFI = \left(\frac{N}{2}\right)\Omega\left[1 + \left(\frac{B}{P}\right)\cos CA\right]$$

$$BPFO = \left(\frac{N}{2}\right)\Omega\left[1 - \left(\frac{B}{P}\right)\cos CA\right]$$

$$BSF = \left(\frac{P}{2B}\right)\Omega\left[1 - \left(\frac{B}{P}\right)^2 \cos^2 CA\right]$$

FTF = fundamental train frequency
BPFI = ball pass frequency, inner race
BPFO = ball pass frequency, outer race
BSF = ball spin frequency
RPM = shaft speed

CA = contact angle
Ω = machine speed
N = number of rolling elements
P = pitch diameter, in
B = ball or roller diameter, in

General Guideline Bearing Frequencies (for use in F_{max} selection ONLY)

BPFO = 0.41 x RPM x N BPFI = 0.59 x RPM x N
FTF = 0.41 x RPM BSF = 0.22 x RPM x N

Roll Frequency

$f = \frac{V}{5\pi D}$ V = web velocity, ft/min D = roll diameter, in **f** = frequency, Hz

SIGNAL PROCESSING

RMS peak = 1.414 rms

Resolution

Resolution = (frequency span x window noise factor x 2)/ number of FFT lines
window noise factor = 1.0 for uniform window, 1.5 for Hanning window, 3.8 for flat top window

Data Acquisition Time (DAT) DAT = Number of FFT lines/frequency span

Default Frequency Spans

Operating Speed	= 10 xRPM
Rolling Element Bearings	= 10 x BPFI
Fluid Film Bearings	= 10 xRPM
Valle/Blade Pass	= 3 x # Vanes/Blades x RPM
Electrical	= 3 x 2 x Line Frequency
Gear Mesh	= 3 x Gear Mesh Frequency

Alexandria University | **Faculty of Engineering**
3^{rd} Year Mech. Engineering | **Fluid Mechanics II**
Final Exam. | **January 2016** | **Time allowed: 3hrs.**

Question One

a) Explain very briefly how a **pressure sustaining valve** in a pumping station can maintain pump operation at its optimum operating point.

b) What is the function of air vents in underground tanks, and what is the criteria of selecting the number and size of these vents?

c) Explain very briefly what is meant by **water network quality simulation**?

d) Explain briefly what is meant by '**Rigid Water Column Theory**'

e) A horizontal pipe is supplied from a constant head tank and discharging to the atmosphere. If the valve at the end of the pipe is suddenly opened, draw **clearly** the **pressure-time** relationship that would be recorded at the following three locations: (Assume Ideal Flow)

- **i.** Immediately upstream of the valve
- **ii.** At a mid-point in the pipe.
- **iii.** Near the tank.

f) What is meant by **sudden** valve closure? Explain your answer.

Question Two

Given the network shown in Fig. 1, representing a pump that delivers water from tank 'A' to the customers at 'C' and 'D' and to fill the tank 'F'. The flow into tank "F" is controlled by valve "V" at the beginning of branch EF, as shown in Fig. 1, where 'r' of the valve equals 2. The total heads in tanks A and F are 40m, and 50 m., respectively, measured from the same datum. The diameters and lengths of the branches are as follows,

Branch	Diameter of pipe (mm.)	Length of pipe (m.)
BC	400	100
CD	300	50
DE	400	100
BE	300	50
EF	300	50

The coefficient of friction 'f' for all branches is 0.003, and the resistance of branch 'AB' is neglected. The pump flow rate in branch 'AB' can be represented by the quadratic equation $H = r\,Q^2$ where, $r = 1$ and H is the difference in head before and after the pump.

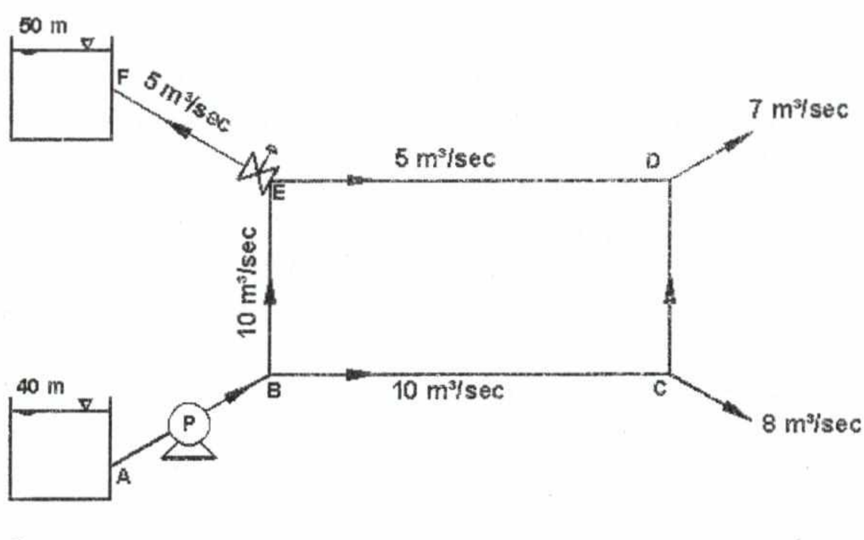


Fig.1

a- Assume the initial flow rate in the branches is given as shown in Fig. 1 Find the flow rate in each branch **after one trial only**, and then find the pressure head at point 'D' if the pressure head before the pump immediately is 10m.

b- For the calculated flow rates, if tank F started to be full, valve 'V' is closed suddenly, estimate the minimum pressure in the branch 'EF' and predict if column separation would occur, if vapor pressure equals –10 m.

Valve closes linearly in 10 sec. and the elevation of "E" is zero.

Question Three

An oil transport pipe line system consists of a pumping station (represented by tank 'A' followed by a non-return valve 'B'), an isolation valve 'C' at a river crossing and tank 'D' representing the tank farm at the end of the line as shown in Fig .

The pipe line is 300 mm diameter, 10 km. long and the coefficient of friction, f = 0.03. The isolation valve 'C' is located in the middle of the pipe line.

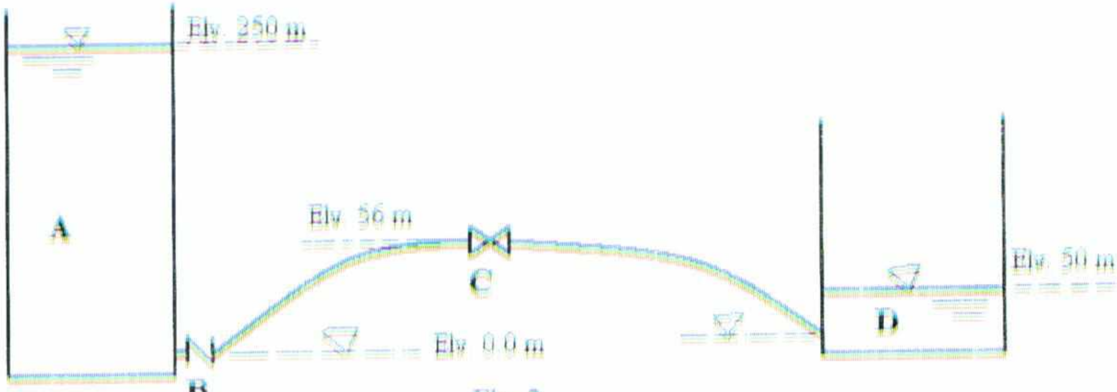


Fig. 2

If, for emergency reasons, you have to stop the flow, which of the following two scenarios would you choose:

i-To shut down the pumping station represented by closing the non-return valve 'B' linearly in 40 seconds, OR

ii-To close the isolation valve 'C' linearly in 500 sec. and at a later time shut down the pump.

Given the vapor pressure P_v = -6 m. oil at the working temperature, neglecting all secondary losses and assuming the gravitational acceleration 'g'= 10 m/sec2 and the maximum allowable head = 300 m. oil.

Question Four

Fig. 3 shows the cross section of a parallel disc viscometer, which consists of two circular horizontal disks, each of radius R, spaced by a vertical distance H; the gap is filled by a liquid of constant viscosity μ and constant density ρ. The upper disk is stationary, and the lower disk is rotated at a steady angular velocity ω in the θ direction. There is only one nonzero velocity component, v_θ, so the liquid everywhere moves in circles. You are required to:

i. Simplify the general continuity equation in cylindrical coordinates, and hence deduce the coordinates (r, θ, z) on which v_θ may depend.

ii. Consider the θ-momentum equation, and simplify it by eliminating all zero terms.

iii. Substitute $v_\theta = \omega r f(z)$ into the simplified θ-momentum equation and determine the final form of $f(z)$, using the boundary conditions at the upper and lower disks.

iv. Explain briefly the logic of assuming that the velocity in the θ direction is of the form $v_\theta = \omega r f(z)$.

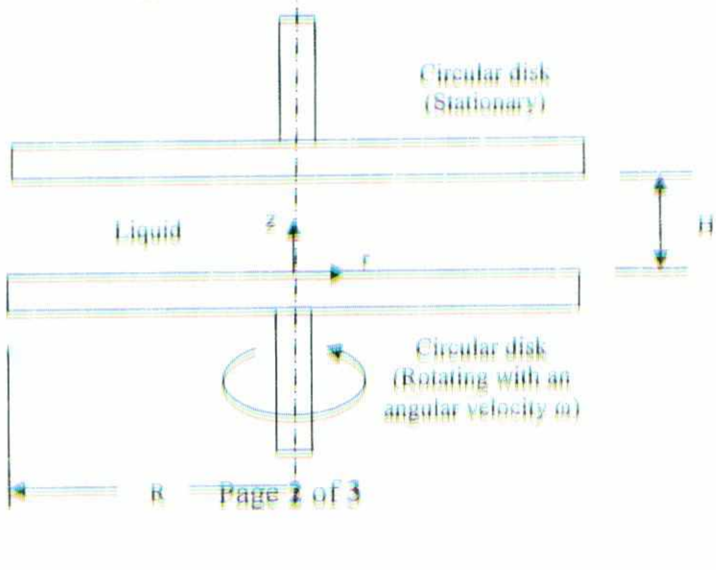


Fig. 3

Question Five

The velocity profile of a steady incompressible laminar flat plate boundary layer of boundary layer thickness δ is approximated by the following parabolic polynomial approximation

$$u = \begin{cases} U\left[2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2\right] & for\ y < \delta \\ U & for\ y \geq \delta \end{cases}$$

It is required to:

(a) Derive expressions for displacement thickness and momentum thickness as functions of boundary layer thickness.

(b) Compare the values of δ^*/δ and θ/δ obtained from part (a) with those of the Blasius solution.

(c) Is the parabolic velocity profile a good approximation for the laminar flat plate boundary layer or not? Explain.

Question Six

(a) Explain what is meant by the Magnus effect.

(b) Explain why the surface of golf balls is deliberately dimpled.

(c) Wind at standard conditions (ρ=1.2 kg/m^3) is blowing past a chimney 30 m high and 80 cm in diameter. If the chimney fractures at a base bending moment of 486 kN.m, and its drag coefficient based on frontal area is 0.5, what is the maximum allowable wind velocity to avoid fracture?

(d) Consider an aircraft that takes off at 190 km/h when it is fully loaded. If the weight of the aircraft is increased by 20%, determine the speed at which the overloaded aircraft will take off.

Integrated Form of Euler's equation: $-\frac{1}{w}(P_2 - P_1) - (Z_2 - Z_1) - \frac{fLv^2}{2gd} = \frac{L}{g}\frac{dv}{dt}$

Hardy Cross method: $\Delta Q = -\frac{\Sigma r Q_o |Q_o|^{n-1}}{\Sigma r n |Q_o|^{n-1}}$

Boundary layer definitions: $\delta^* = \int_0^\delta \left(1 - \frac{u}{U}\right) dy$, $\theta = \frac{u}{U}\int_0^\delta \left(1 - \frac{u}{U}\right) dy$

$$\frac{\partial v_r}{\partial r} + \frac{v_r}{r} + \frac{1}{r}\frac{\partial v_\theta}{\partial \theta} + \frac{\partial v_z}{\partial z} = 0$$

$$\rho\left(\frac{\partial v_\theta}{\partial t} + v_r\frac{\partial v_\theta}{\partial r} + \frac{v_\theta}{r}\frac{\partial v_\theta}{\partial \theta} + \frac{v_r v_\theta}{r} + v_z\frac{\partial v_\theta}{\partial z}\right) = \rho g_\theta - \frac{1}{r}\frac{\partial p}{\partial \theta} + \mu\left(\frac{\partial^2 v_\theta}{\partial r^2} + \frac{1}{r}\frac{\partial v_\theta}{\partial r} - \frac{v_\theta}{r^2} + \frac{1}{r^2}\frac{\partial^2 v_\theta}{\partial \theta^2} + \frac{2}{r^2}\frac{\partial v_r}{\partial \theta} + \frac{\partial^2 v_\theta}{\partial z^2}\right)$$

================ Good Luck ====================== Dr. Hassan A. Warda

Dr. Essam M. Wahba