L-4/T-1/ME **Date : 20/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **ME 415** (Refrigeration and Building Mechanical Systems)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

Symbols used have their usual meaning and interpretation. Assume reasonable value for any missing data. The Refrigeration and A/C Data Book will be provided.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Why the outdoor air is required in air conditioning system? Compare all air and all water system with schematic diagram. Make comparison between ducted split type, multiple split type and VRE type air-conditioning system with schematic diagram. **(15)**

   (b) A fish freezing plant uses three stage compression refrigeration system with inter-cooling and removal of flash gas. Calculate the power required by the three compressors in a R134a system which serves a 60 TR evaporator at −30°C, 50 TR evaporator at −20°C and 40 TR evaporator at −10°C. The condensing temperature is 30°C and the intercooler temperature is −20°C and −10°C. Draw the schematic diagram and P-h diagram of the system. Also calculate the COP of the system. **(20)**

2. (a) A packaged air conditioner serves four rooms in an apartment. The schematic layout of the duct system, together with the volume flow rate to each room, is shown in Fig. for Q. No. 2(a). (i) Size the duct system using the equal-friction method. The duct shall be of standard round sections with diameters in increments of 25 mm. The air velocity in the first section is not to exceed 8 m/s. (ii) Estimate the static pressure in the index run of the duct network. There is a pressure drop of 25 Pa at each of the outlet grills at E, F, G and H. In the calculation, consider the resistance due to the elbow and Tee as 10 Pa and 15 Pa, respectively. **(20)**

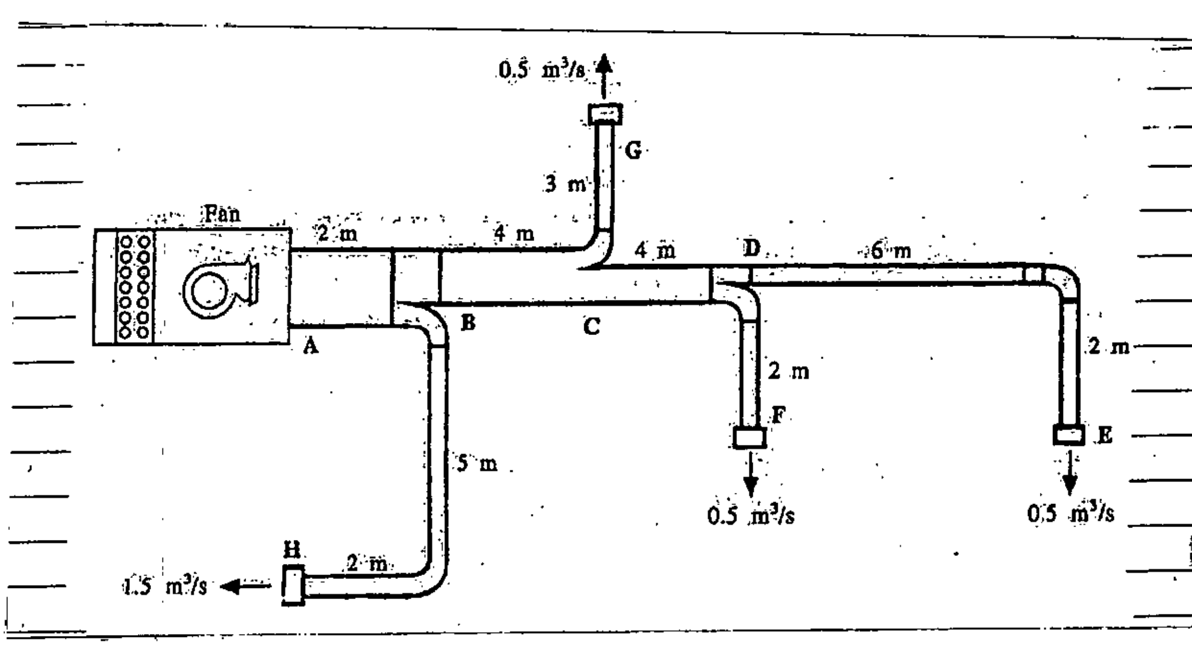

Figure for the Q. No. 2(a)

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(b) What are the main sources of fire? Why is fire such a devastating hazard in Bangladesh? What is the fire safety concept tree? **(15)**

3. (a) Classify fire according to BNBC with examples. Write short note on evacuation and fire growth. **(10)**

(b) Describe different way of extinguishment of fire. Make comparison among different types of fire extinguisher and specify which type of extinguisher will be used for different class of fire. Describe sprinkler fire protection system. **(25)**

4. (a) Classify elevators. Draw the schematic diagram of an electric traction lift and show its different components. What are the typical factors to be considered in the design of elevators? **(25)**

(b) Draw the schematic diagram of different arrangements of escalator. For an escalator of 35° incline, two passengers per step, speed of 0.6 m/s and 600 mm step length, determine the number of persons moved per hour. **(10)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Classify different types of compressors used in refrigeration systems. Describe the working principle of a scroll compressor with proper schematic diagram. **(17)**

(b) Describe the working principle of an evaporative condenser with necessary diagram. Identify the major components of an evaporative condenser and mention their functions. **(18)**

6. (a) Though the temperature at high altitude is lower than the earth surface, aircraft needs cooling, why is this cooling necessary? Hence, describe an air cycle refrigeration system with proper schematic diagram. **(17)**

(b) Describe an electronic expansion valve (EXV). What are the benefits of an electronic expansion valve used in a refrigeration system? Also explain how its controller system works. **(18)**

Contd P/3

7. (a) Describe the Linde liquefaction plant for liquifying gas with neat sketch. Draw the necessary T-s diagram and explain. **(17)**

   (b) In a vapor absorption refrigeration system using LiBr, T_G = 100°C, T_E = 9°C, T_a = 28°C, and T_c = 43°C. Estimate the value of COP for: **(18)**

   (i) Carnot cycle

   (ii) Real cycle if pump delivers 0.5 kg/s solutions

   (iii) If a heat exchanger is inserted after the pump and the water enters the generator at 50°C.

8. Estimate the cooling load of a class-room for 60 students at 4 pm for the following conditions: **(35)**

Location	: Dhaka
Date	: April 15
Floor	: 8m x 7m, 3.5m height
Roof	: Type 5, without suspended ceiling and added with 25 mm wood, 25 mm insulation.
Walls	: 254 mm brick with 12.5 mm plaster on both sides
Windows	: 15% of wall area on north and west walls. 10 mm clear glass, $U = 2.9\ W/m^2.°C$
Light	: 25 W/m^2 fluorescent bulbs.

   (i) Assume standard indoor conditions as recommended in ASHRAE.

   (ii) Assume no heat transfer through floor, south and east walls.

   (iii) Assume reasonable electrical appliances.

L-4/T-1/ME **Date : 25/09/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **ME 417** (Internal Combustion Engines)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Explain the physical meaning of SIT. **(5)**

(b) Mention some of the key characteristics of premixed flanses. **(10)**

(c) Explain the physical meaning of laminar burning velocity. **(10)**

(d) Make a brief comparison between knocks in SI and CI engines. **(10)**

2. (a) Write a short note on 'wiebe function.' **(5)**

(b) Why increase in ambient temperature reduces engine output power with slight improvement in fuel economy? **(10)**

(c) Explain the physical mechanism of knock in SI engine. **(10)**

(d) Explain the phases of combustion in CI engines. **(10)**

3. (a) Mention the key factors to affect eingine volumetric efficiency. **(5)**

(b) Why engine inlet valves are made larger than exhaust valves? **(10)**

(c) Why engine inlet valves are opened earlier and closed later? **(10)**

(d) Explain 'similitude' used in engine design. Show how it is used to address the engine coolant temperature effect on volumetric efficiency. **(10)**

4. (a) Explain the deviations between actual engine cycle and air-standard cycle. **(5)**

(b) Derive the engine power equation:

$$bmep = \eta_i \eta_c \eta_m \eta_v \left\{ \rho_{a,i.} \left(\frac{F}{A} \right) . Q_{LHV} . \right\}$$

Explain the physical interpretation of all the efficiency terms present in the equation. **(30)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

Symbols indicate their usual meanings. Assume any missing data.

5. (a) Two automobile engines have the same total displacement volume and the same total power produced within the cylinders. List the possible advantages of: (i) A V6 over a straight six. (ii) A V8 over a V6. (iii) A V6 over a V8. **(6)**

Contd P/2

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Contd ... Q. No. 5

(b) Why do most very small engines operate on a two-stroke cycle? (ii) Why do most very large engines operate on a two-stroke cycle? (iii) Why do most automobile engines operate on a four-stroke cycle? (iv) Why would it be desirable to operate automobile engines on a two-stroke cycle? **(10)**

(c) Explain why an idling SI engine requires a rich mixture of fuel and air. How is this requirement fulfilled in a carbureted engine and in an EFI system? **(12)**

(d) What will happen if diesel fuel is used in a SI engine? and Octane is used in a CI engine? **(7)**

6. (a) Draw typical ideal and actual P-v diagram of an Otto engine cycele and point out the losses in actual cycle. **(10)**

(b) A Four-cylinder, 2.5-liter, SI automobile engine operates at WOT on a four-stroke air-standard Otto cycle at 3000 rpm. The engine has compression ratio of 8.6:1, a mechanical efficiency of 86%, and a stroke-to-bore ratio S/B=1.025. Fuel is isoocate with AF=15, a heating value of 44,300 kj/kg, and combustion efficiency, η_c = 100%. At the start of the compression stroke, conditions in the cylinder combustion chamber are 100 kPa and 60°C. It can be assumed that there is a 4% exhaust residual left over from the previous cycle. Do a complete thermodynamic analysis of this engine. **(25)**

7. (a) Calculate the stoichiometirc air-fuel ratio for ehanol and compare this value to that for gasoline. Assume the gasoline can be represented as $C_{7.76}H_{13.1}$. **(15)**

(b) A gasoline-type fuel is generated by blending 15% by weight butane-1, 70% triptane, and 15% isodecane.

Determin: **(12)**

(i) the anti-knock index

(ii) The anti-knock index if 0.4 gm of TEL is added per liter of fuel

(iii) if the fuel is sensitive to combustion chamber geometry.

(c) With a block diagram show how lubricating oil is circulated in the engine. **(8)**

8. (a) Mension some of the key characteristics of different types of dynamometers. **(10)**

(b) Discuss the two types of cooling system of IC engines and compare them. **(5)**

(c) Discuss with neat sktch(es), the construction and operation of a three way catalytic converter. **(15)**

(d) What is EGR? How does it relate with the throttle valve? **(5)**

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Appendix-

PROPERTIES OF FUELS

Fuel		Molecular Weight	Heating Value HHV (kJ/kg)	Heating Value LHV (kJ/kg)	Stoichiometric $(AF)_s$	Stoichiometric $(FA)_s$	Octane Number MON	Octane Number RON	Heat of Vaporization (kJ/kg)	Cetane Number
gasoline	C_8H_{15}	111	47300	43000	14.6	0.068	80–91	92–99	307	
light diesel	$C_{12.3}H_{22.2}$	170	44800	42500	14.5	0.069			270	40–55
heavy diesel	$C_{14.6}H_{24.8}$	200	43800	41400	14.5	0.069			230	35–50
isooctane	C_8H_{18}	114	47810	44300	15.1	0.066	100	100	290	
methanol	CH_3OH	32	22540	20050	6.5	0.155	92	106	1147	
ethanol	C_2H_5OH	46	29710	26950	9.0	0.111	89	107	873	
methane	CH_4	16	55260	49770	17.2	0.058	120	120	509	
propane	C_3H_8	44	50180	46190	15.7	0.064	97	112	426	
nitromethane	CH_3NO_2	61	12000	10920	1.7	0.588			623	
heptane	C_7H_{16}	100	48070	44560	15.2	0.066	0	0	316	
cetane	$C_{16}H_{34}$	226	47280	43980	15.0	0.066			292	100
heptamethylnonane	$C_{12}H_{34}$	178			15.9	0.063				15
α-methylnaphthalene	$C_{11}H_{10}$	142			13.1	0.076				0
carbon monoxide	CO	28	10100	10100	2.5	0.405				
coal (carbon)	C	12	33800	33800	11.5	0.087				
butene-1	C_4H_8	56	48210	45040	14.8	0.068	80	99	390	
triptane	C_7H_{16}	100	47950	44440	15.2	0.066	101	112	288	
isodecane	$C_{10}H_{22}$	142	47590	44220	15.1	0.066	92	113		
toluene	C_7H_8	92	42500	40600	13.5	0.074	109	120	412	
hydrogen	H_2	2	141800	120000	34.5	0.029		90		

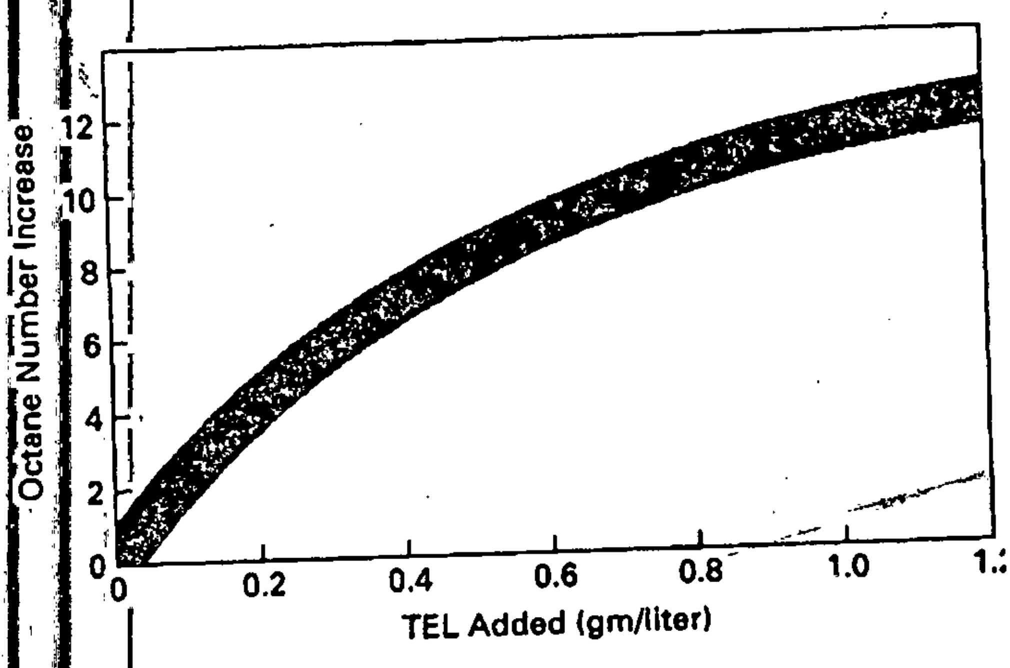

Fig-: Octane number as a function of TEL added to octane

L-4/T-1/ME Date : 26/10/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **ME 421** (Fluid Machinery)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

Assume any reasonable value for missing data.

1. (a) Explain the significance of impulse-momentum principle for the operation of fluid machinery. **(5)**

(b) Why is the bottom portion of the bucket of a Pelton wheel cut? Find a relation between the speed of jet and that of the wheel of a Pelton wheel for maximum efficiency. **(15)**

(c) A jet of water 6 cm in diameter impinges on a curved vane and is deflected through an angle of 165°. The vane moves in the same direction as that of the jet with a velocity of 40 m/s. The rate of flow is 180 lit/s. Determine (i) the components of force, (ii) hp developed, and (iii) hydraulic efficiency. Neglect friction. **(15)**

2. (a) What is the function of nozzle and spear mechanism used in Pelton wheel? Briefly describe the working proportions related to the components of Pelton turbine. **(17)**

(b) An inward flow reaction turbine is supplied with 100 cumec of water under an effective head of 150 m. The inner and outer diameters of the runner are 2.5 m and 3.5 m respectively. If the inlet vane angle is 120°, the hydraulic efficiency is 85% and the discharge is radial with a velocity of 15 m/s, find the power developed and the speed of the runner. Also calculate the breadth ratio and speed ratio. The breadth of the runner is constant. **(18)**

3. (a) Derive the expressions of unit speed, unit power and unit discharge of a turbine. Explain the significance of these parameters. **(17)**

(b) A hydroelectric power station is supplied with 175 m^3/s of water under a head of 20 m. If the overall efficiency is 80%, find the number of Francis turbines required for 161 rpm of each turbine and a specific speed of 200. **(18)**

4. (a) What is fluid coupling? Give the comparison between fluid coupling and torque converter related to their performance. **(10)**

(b) Briefly explain the performance of different types of hydraulic turbines. **(10)**

(c) A Kaplan turbine develops 33000 kW under a head of 40 m. The speed ratio is 2.1 and the flow ratio is 0.62. The ratio of boss and runner diameter is 0.36. If the hydraulic and mechanical efficiencies of the turbine are 86% and 95%, respectively, calculate the runner diameter, speed and specific speed of the turbine. **(15)**

Contd P/2

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

Symbols have their usual meaning. Assume reasonable values for missing data.

5. (a) Discuss the effect of outlet blade angle on the performance of a centrifugal pump. What is shut-off head? **(8)**

(b) Why can the suction lift of a centrifugal pump not exceed a certain limit? Explain. **(7)**

(c) The impeller of a centrifugal pump has an outer diameter of 25 cm and rotates at a speed of 1500 rpm. The impeller has 10 blades, each of 5 mm thickness. The blades are backward facing at 30° to the tangent. The breadth of the flow passages at the outlet is 12.5 mm. Pressure gauges are fitted close to the pump at the suction and discharge pipes and both are 2.5 m above the water level of the supply sump. When the discharge is 26 L/s, the pressure readings are 4 m water (vacuum) in the suction end and 16.5 m of water (gauge) at the delivery end of the pump. If 50% of velocity is recovered as static head in the volute section, estimate (i) theoretical head, (ii) manometric efficiency, (iii) losses in the impeller, and (iv) capacity of the motor to drive the pump, if the mechanical efficiency of the pump is 0.9. **(20)**

6. (a) What do you understand by the 'operating point' of a centrifugal pump? Explain how the operating point of a pump pipeline system is determined when **(12)**

(i) a single pump is working.

(ii) series duplex pumps are working.

(iii) parallel duplex pumps are working.

(b) A pump is to deliver water from a sump against a total static head of 12 m. The details of suction and delivery pipes are as follows;

Suction Pipe	**Delivery Pipe**
Length = 2.5 m	Length = 400 m
Diameter = 15 cm	Diameter = 20 cm
Friction factor f = 0.018	Friction factor f = 0.020

The pump characteristic is given by the equation $H = 35 - 2200\,Q^2$ where H = total pump head in meters and Q = discharge in m^3/s. Assuming an efficiency of 0.70. determine the operating point and power required by the pump. What is the value of shut-off head of the pump? Neglect minor losses. **(15)**

(c) At the normal operating point, a centrifugal pump with one stage delivers 0.3 m^3/s against a head of 30 m at a speed of 1500 rpm. At another site it is required that 0.4 m^3/s be raised over a height of 105 m by using a similar pump operating at the same speed but with multistage. How many stages are required? **(8)**

ME 421

7. (a) What is 'negative slip' in a reciprocating pump? Derive the expresson of acceleration head developed in a reciprocating pump and discuss the variation of pressure due to acceleration of piston. **(17)**

(b) A single acting reciprocating pump has a bore of 500 mm and a stroke of 500 mm respectively. The pump delivers 0.11 m^3/s of water against a head of 100 m. The head losses due to friction in suction and delivery pipes are 2 m and 14 m, respectively. The velocity of water in the pipe is 1.5 m/s. If the pump efficiency is 90%, and the slip is 5%, calculate the speed of the pump and the power required to drive the pump. **(18)**

8. (a) What is an air vessel? Determine how much work is saved by fitting air vessels on a double acting reciprocating pump. Is the result same for a single acting reciprocating pump? If not, explain why? **(22)**

(b) A centrifugal pump can deliver a discharge of 0.10 m^3/s of water to a head of 30 m. The critical cavitation number σ_c for the pump is found to be 0.12. The pump has a suction lift of 6.0 m. Given that the atmospheric pressure head is 10.30 m, vapour pressure head is 0.33 m and friction losses in the suction pipe is 0.47 m, Estimate the NPSHA. If a margin of 1.0 m is mandatory, is the installation safe against cavitation? **(13)**

L-4/T-1/ME **Date : 16/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **ME 423** (Fluids Engineering)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Explain the following terms: (i) Compressibility factor, (ii) Reduced temperature and (iii) Pseudo-reduced temperature. **(12)**

(b) Distinguish between specific gravity and gas gravity of a gas. **(5)**

(c) A natural gas mixture consists of the following components: **(18)**

Component Gas	Mole fraction	Molecular weight	Critical Temp., °F	Critical Pressure, Psia
C_1	0.847	16.04	-117	667.0
C_2	0.007	30.07	90.07	707.80
C_3	0.003	44.10	206	617.00
N_2	0.016	28.01	-232.48	492.80
CO_2	0.012	44.01	87.73	1071.00
H_2S	0.115	34.08	212.40	1306.00

(i) Calculate the apparent molecular weight, gravity, pseudocritical temperature and pseudo-critical pressure of the gas.

(ii) Using the Standing-Katz chart, determine the compressibility factor of the gas at 100°F and 1400 psia.

Use the following correlations, if required.

$$\varepsilon = 120(A^{0.9} - A^{1.6}) + 15(B^{0.5} - B^{4.0})$$

where

ε = adjustment factor, °R

A = sum of the mole fractions of CO_2 and H_2S

B = mole fraction of H_2S

$$T'_{pc} = T_{pc} - \varepsilon$$

$$P'_{pc} = \frac{P_{pc} \times T'_{pc}}{T_{pc} + B(1-B)\varepsilon}$$

where

T'_{pc} = adjusted pseudo-critical temperature, °R

P'_{pc} = adjusted pseudo-critical pressure, psia.

Contd P/2

2. (a) What is line pack volume in a gas pipeline? Describe an expression in USCS units for calculating line pack volume. **(12)**

(b) A natural gas pipeline is 10 mi long and has an inlet pressure of 1000 psig and outlet pressure of 900 psig when transporting 100 MMSCFD. The base pressure and base temperature are 14.7 psia and 60°F, respectively. If the pipe is NPS 16, 0.250 in. wall thickness, calculate the line pack assuming an average gas temperature of 78°F. Use an average compressibility factor of 0.90 and average pressure determined by the following relation. **(8)**

$$P_{avg} = \frac{2}{3}\left(p_1 + p_2 - \frac{p_1 p_2}{p_1 + p_2}\right)$$

(c) A series piping system, shown in figure for Q. 2(c), consists of 12 mi of NPS 16, 0.375 in. wall thickness connected to 24 mi of NPS 14, 0.250 in. wall thickness and 8 miles of NPS 12, 0.250 in. wall thickness pipes. Calculate the inlet pressure required at the origin A of this pipeline system for a gas flow rate of 100 MMSCFD. Gas is delivered to the terminus B at a delivery pressure of 500 psig. Gas gravity and viscosity are 0.6 and 0.000008 lb/ft-s, respectively. The gas temperature is assumed constant at 60°F. Use a compressibility factor of 0.90 and the General Flow equation with Darcy friction factor = 0.02. The base temperature and base pressure are 60°F and 14.7 psia, respectively. **(15)**

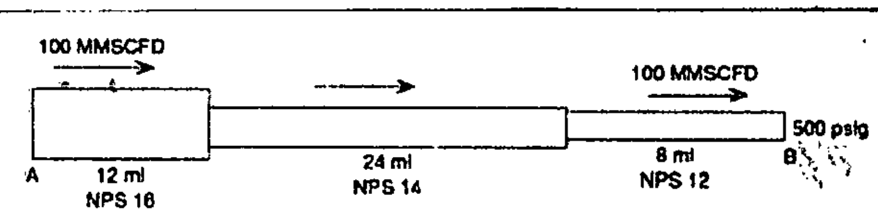

Figure for Q2c

The general flow equation in USCS unit system is:

$$Q = 38.77F\left(\frac{T_b}{P_b}\right)\left(\frac{P_1^2 - P_2^2}{GT_fLZ}\right)^{0.5} D^{2.5}$$

3. (a) Discuss on 'in-situ concentration' and 'delivered concentration' in a slurry flow. Establish a relation between them as a function of 'hold up'. **(8)**

(b) What is 'terminal settling velocity'? Derive the equation of terminal settling velocity for the Stokes' law range and the Newton's law range. **(12)**

Contd P/3

ME 423

Contd...Q. No. 3

(c) Estimate the terminal velocity and hindered settling velocities of sand particles of 200 micron size (Take, density = 2650 kg/m^3, shape factor K = 0.26 and velocity ratio ξ = 0.55) in water at room temperature (Take, density = 998 kg/m^3 and dynamic viscosity = 1.002 × 10^{-3} Pa-s). Use the following correlation. Take, C_v = 0.2. **(15)**

$$\frac{V_t}{V^*} = \frac{Re^*}{3\left(1+0.08Re^{*1.2}\right)} + \frac{2.8}{1+30000Re^{*-3.2}}$$

4. (a) Distinguish between Homogeneous and Pseudo-Homogeneous slurry flows. **(5)**

(b) What is a rheogram? Discuss various rheological models. **(12)**

(c) Define the terms-head reduction factor, efficiency reduction factor and delivered volumetric concentration in connection to a slurry handing pump. How are they related in case of a centrifugal pump? **(9)**

(d) Determine the head reduction factor, R_H for a pump with an impeller diameter of 1 m pumping an ore product (S_S = 2.8) with d_{50} = 400 μm, X_h = 0.26 and delivered volumetric concentration of 21%. Use the following correction factor for specific gravity **(9)**

$$\left[\frac{S_S - 1}{1.65}\right]^{0.65}$$

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

Moody diagram is supplied.

Assume reasonable value for missing data. Symbols have their usual meaning.

5. (a) The pump as shown in Fig. for Q. No. 5(a) has the characteristics curve as shown in Fig. for Q. No. 5(a). **(17)**

   (i) Estimate the flow rate and power required by the pump if its overall efficiency is 60%

   (ii) Sketch the EGL and the HGL

   (iii) If cavitation is possible, find the maximum distance from the reservoir to locate the pump.

(b) A 250 mm diameter pipe is 1600 m long. When the discharge is 0.1 m^3/s in this pipe, the pressure drop between the ends of the pipe is measured as 100 kPa. The elevation at the end of the pipe is 10 m below from its beginning. Determine: **(18)**

   (i) the type of flow, (ii) equivalent sand-grain roughness of the pipe wall, (iii) Hazen-Williams roughness coefficient, (iv) energy dissipation by the fluid friction per hour. Use $\nu = 1.31 \times 10^{-6}$ m^2/s,

Contd P/4

6. (a) A liquid with a specific gravity of 0.7 is pumped from a storage tank to a free jet discharge through a pipe of length L and diameter D as shown in Fig. for Q. No. 6(a). The pump provides a fluid power W_f to the liquid. Assuming a constant friction factor of 0.015, determine the discharge for the following conditions: z_1 = 75 ft, P_1 = 15 lb/in^2, z_2 = 55 ft, L = 1500 ft, D = 8 in, W_f = 12 hp. **(17)**

   (b) For the three branch piping system as shown in Fig. for Q. No. 6(b). The following data are given:

Pipe	L(m)	D(m)	f	Σk
1	510	0.1	0.025	4
2	740	0.15	0.02	3
3	900	0.13	0.018	7

   Determine the flow rates through different pipes and the piezometric head at the junction. Assume constant friction factors. **(18)**

7. (b) Water is being pumped in the piping system as shown in Fig. for Q. No. 7(a). The pump curve is approximated by the relation $H_p = 150 - 5Q_1^2$, where Hp in meters and Q_1 in m^3/s. The pump efficiency is 75%, compute the flow distribution in pipes and the required pump power. **(17)**

   (b) A 5-pipe and 3 node network is shown in Fig. for Q. No. 7(b). On the diagram the first number along each line is the pipe diameter in inches and the second number is the pipe length in feet. All pipes have same roughness e = 0.001 ft. (i) compute the values of k and n for pipe 1 based on the Darcy-Weisbach equation, (ii) Write the system of Q equations for the network, and (iii) Find the pressure at each node. **(18)**

8. (a) For incompressible flow in an inelastic pipe show that the velocity does not vary with the excitation position of the valve but only with time. Mention the assumptions for this proof. **(17)**

   (b) A steel pipe of E = 210 MPa, L = 1500 m, D = 280 mm, e = 10 mm conveys water of bulk modulus 220 × 10^7 Pa. The initial velocity is 1.2 m/s. A valve at the downstream end is suddenly closed reducing the velocity to zero. Determine the pressure pulse wave speed in the pipe, the speed of sound in an unbounded water medium, the pressure rise at the valve, the time it takes for the wave to travel from the valve to the reservoir at the upstream end, and the period of oscillation. **(18)**

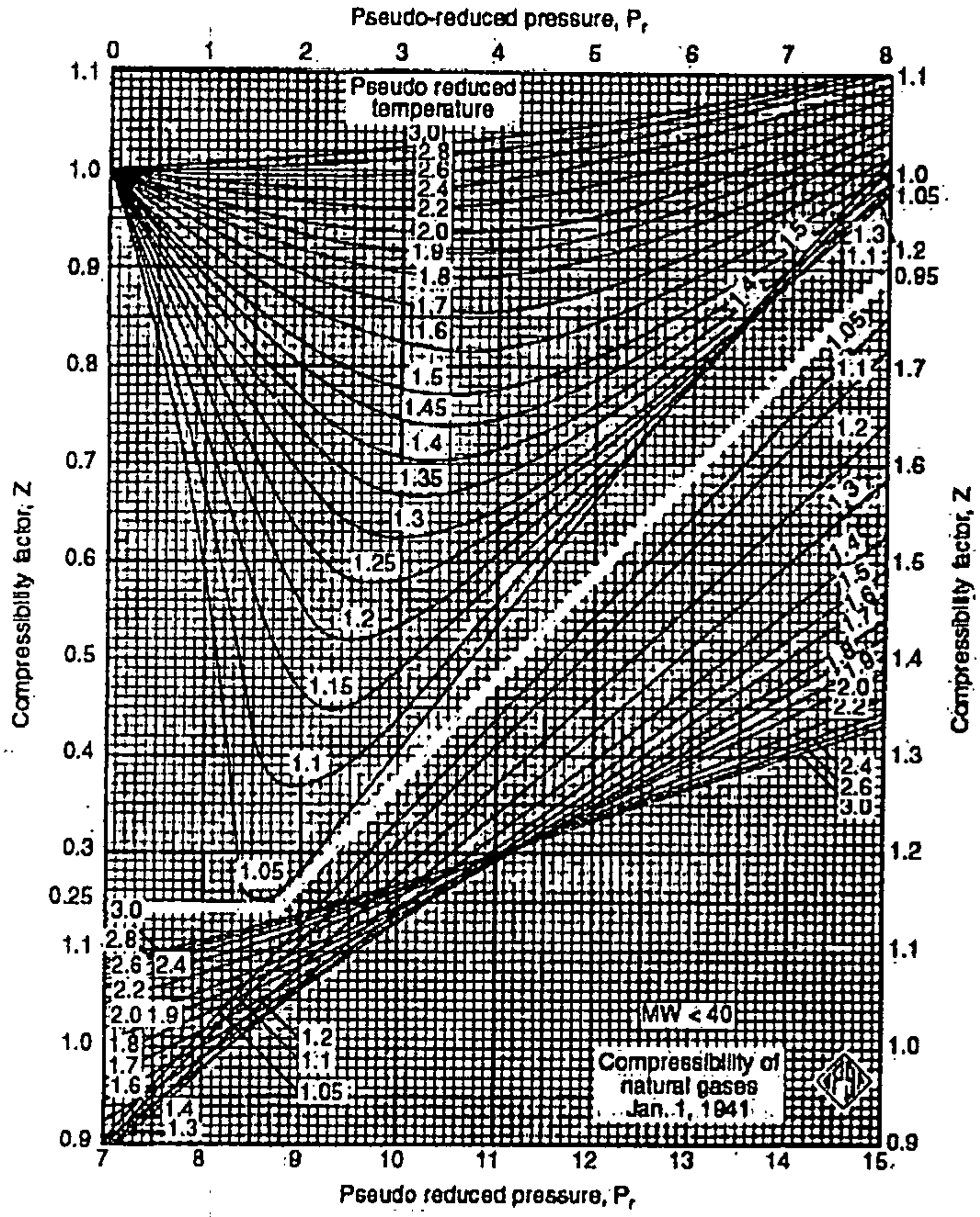

Figure 1.2 Compressibility factor chart for natural gases. (From Gas Processors Suppliers Association, *Eng. Data Book*, Vol. II. With permission.)

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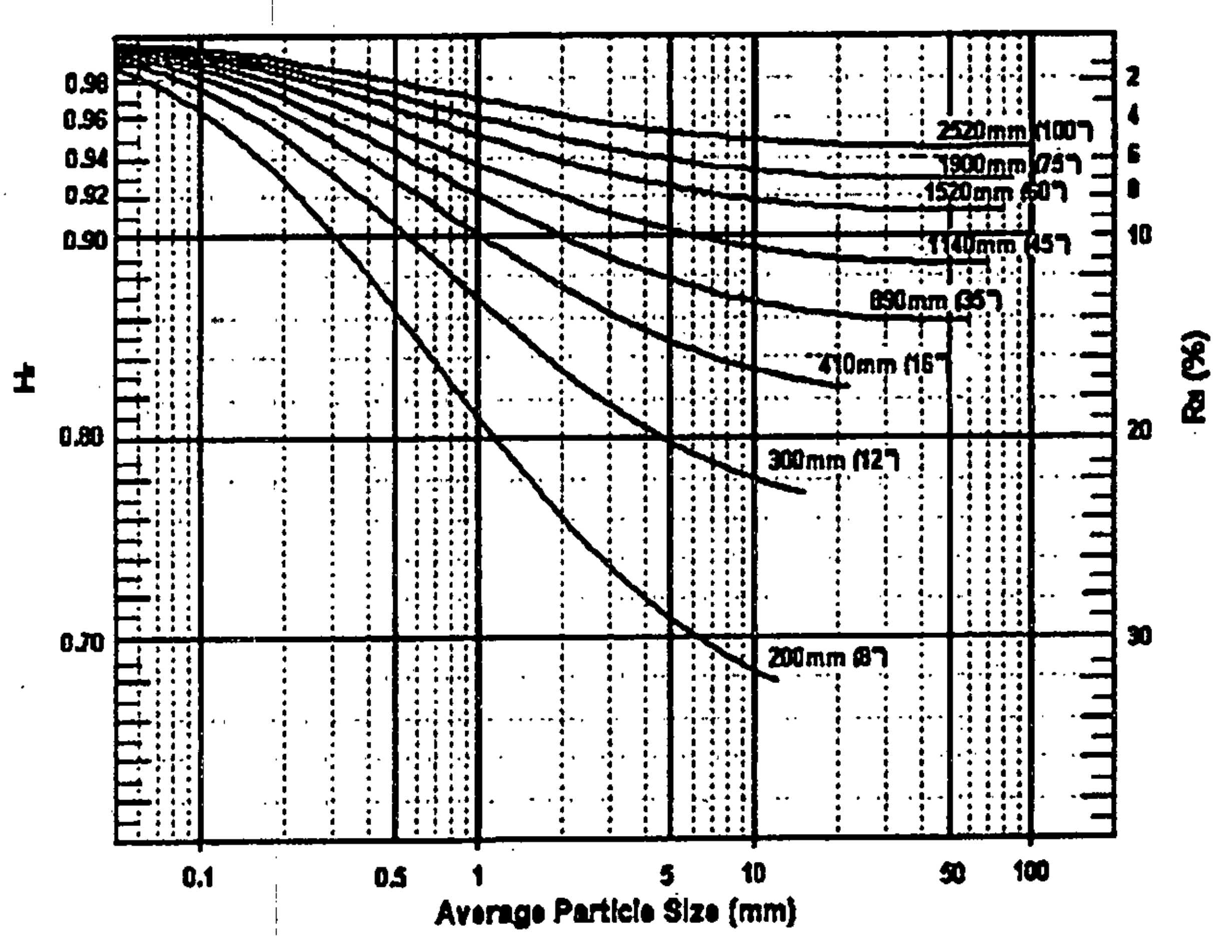


Generalized solids effect diagram for pumps for C_{vd} = 15%, S_s = 2.65 and a negligible amount of fine particles

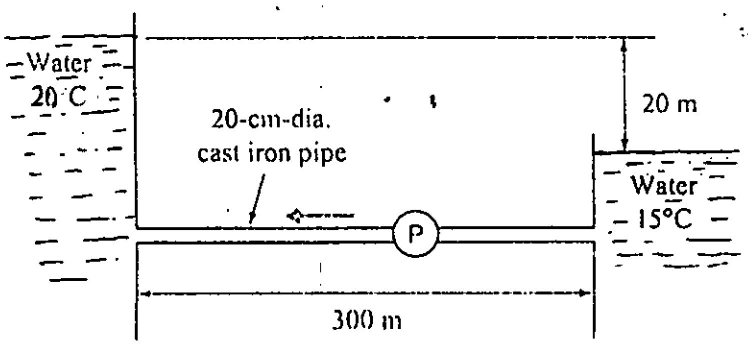
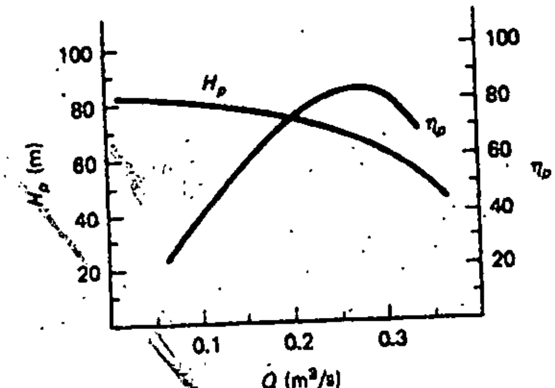


Fig. for Q. NO. 5 (a)



characteristic curve for Q. No. 5 (a)

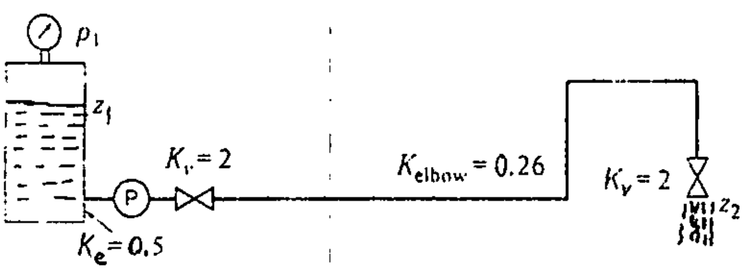


Fig. for Q. No. 6 (a)

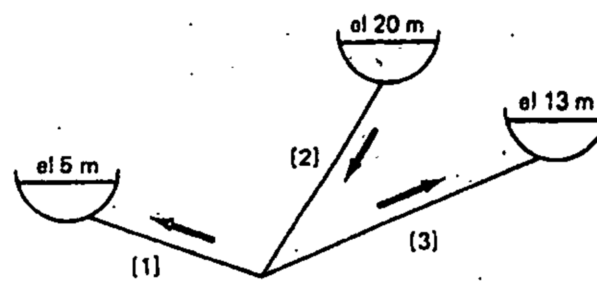


Fig. for Q. NO. 6 (b)

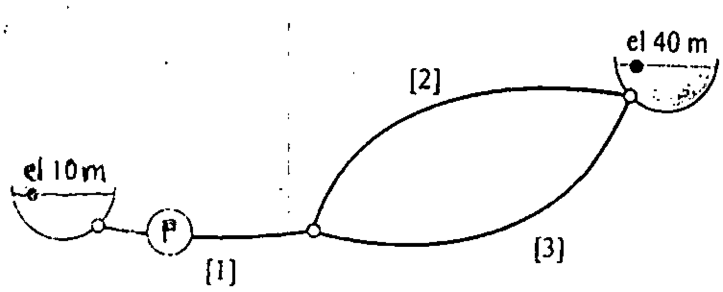
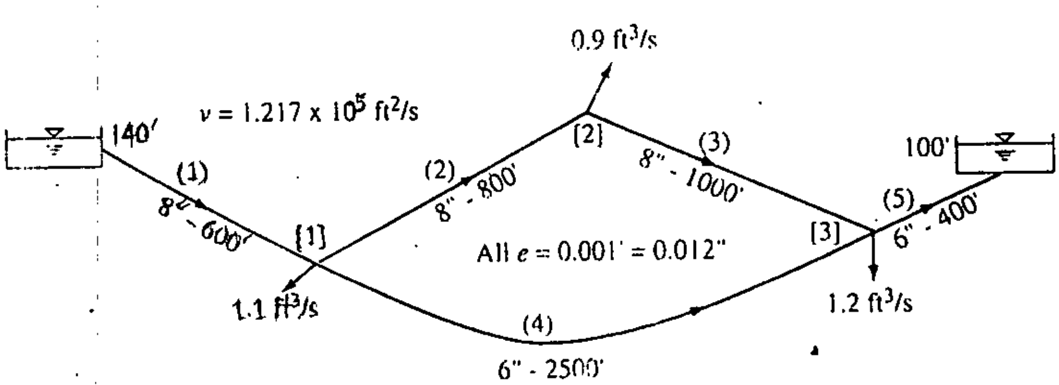


Fig. for Q. NO. 7 (a)

Pipe	$\overline{R}$ (s²/m⁵)
1	400
2	1000
3	1500

characteristic of pipe for Q. NO. 7 (a)



Pipe	K	n
1		
2	3.53	1.961
3	4.44	1.929
4	48.6	1.934
5	6.40	1.817

Fig. for Q. No. 7 (b)

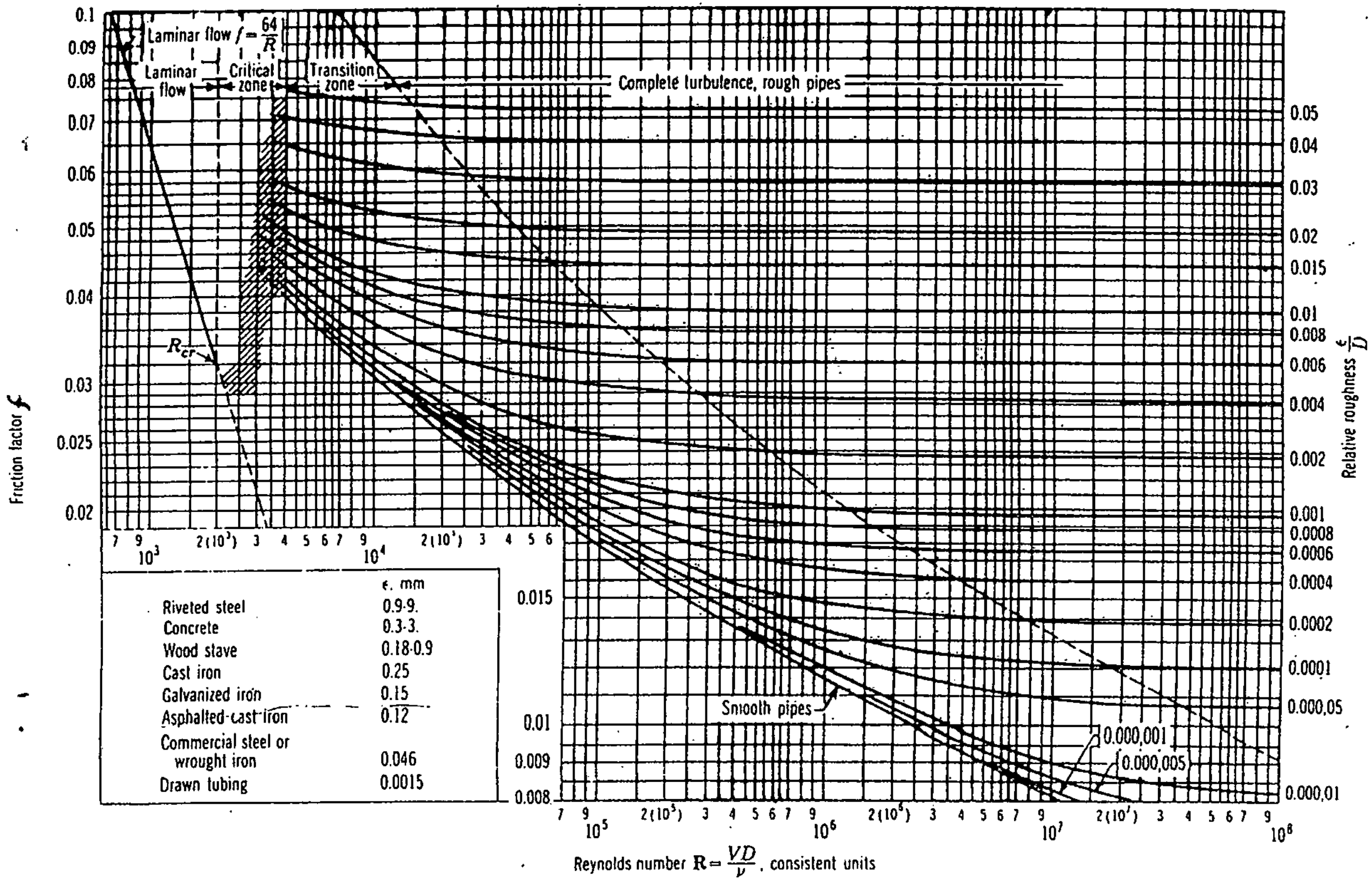


Figure Moody diagram.

L-4/T-1/ME Date: 16/10/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub: **ME 441** (Theory of Structures)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

Symbols have their usual meaning.

1. (a) With the help of a schematic illustration of all possible couples and stress resultants acting at the edges of a thin plate, derive the governing DEQ for lateral deflection in the plate. **(20)**

(b) Consider the following 2-D function

$$\omega(x,y)=\frac{q_o}{8D}\left[x^2y^2-axy(x+y)+a^2xy\right]$$

Mathematically investigate whether the above function would be a suitable choice for the deflection function for a clamped square plate of sides *a*. **(15)**

2. (a) How does a 'Beam-Column' differ from a Beam and a Column? Derive the differential equation that governs the deflection of a beam-column. **(15)**

(b) Consider a one-end fixed and the other end hinged slender column of length, L subjected to an axial compression force, P. **(20)**

Analytically show that the buckling load of the column will be increased 100% if the hinged support at the end is replaced by the fixed support.

3. Assuming a suitable elastic curve for the following beam problem (shown in fig. for Q3), determine the approximate solutions of deflection and bending moment using potential energy method. **(35)**

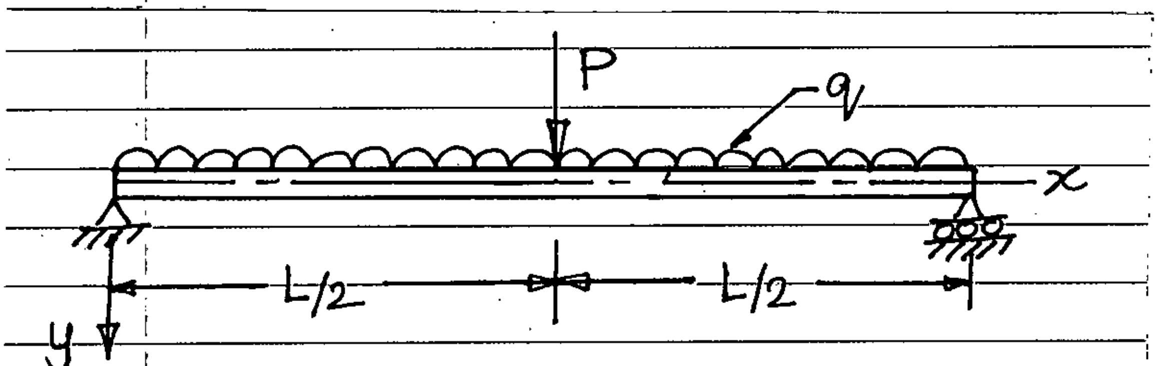


Fig. for Q3

Comment on the accuracy of the approximate solutions by comparing them with those of mechanics of materials.

Contd P/2

4. (a) Define 'Strain Energy Density'. Explaining the concept of strain energy, deduce an expression of strain energy density for general 3-D elastic solids.
   Also show how the strain energy density can be expressed in terms of stiffness and compliance matrices of the material. **(17)**

   (b)

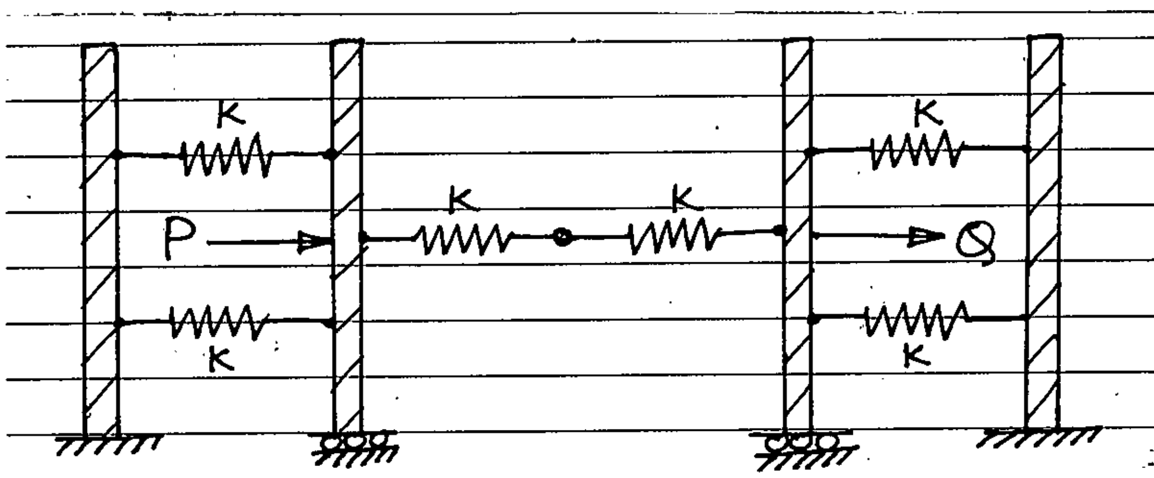


Fig. for Q.4(b)

For the above spring system (Fig. for Q. 4(b)) given that,

Spring stiffness, k = 50 N/mm

Forces, P = 80 N and Q = 100 N

Determine the displacements of the sliding pillars and the spring junction using a suitable energy method. **(18)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) What are the different material models available to describe the stress-strain relation of materials? Discuss. **(10)**
   (b) Define stress. Describe how the stress in a new plane change with angles made with the reference plane. **(10)**
   (c) Derive the 3-D stress-strain relation in terms of Lame's constant, λ and shear modulus, G. **(15)**

6. (a) What is volumetric strain? Derive the limiting value of the Poisson's ratio from volumetric strain. **(20)**

Contd P/3

ME 441

Contd...Q. No. 6

(b) A steel rod of length 0.3 m is subjected to a tensile stress of 100 MPa along the direction of its length. The rod is of area 30mm × 30 mm. Determine the change in volume of the rod. The value of Young's Modulus and Poisson's ratio for steel are 200 GPa and 0.28 respectively. **(15)**

7. (a) What are plane stress and plane strain conditions? Describe plane stress and plan strain problems with practical examples. **(15)**

(b) Let us assume the Airy stress function, $\varphi(x, y)$ shown below is the solution to an elasticity problem, which is a thin rectangular plate as shown in figure 7(b): **(20)**

$$\varphi(x,y)=\frac{x^4}{3}+x^2y^2+2xy^3-\frac{2y^4}{3}$$

(i) Check whether $\varphi(x, y)$ satisfy the governing DEQ of stress functions.

(ii) Determine the state of stress and show it on the rectangular body.

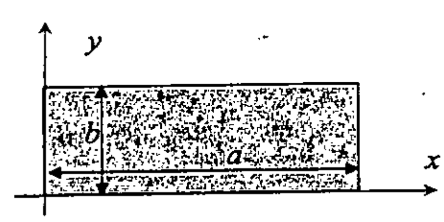


Fig. 7(b)

8. (a) With appropriate figures, show how the six tangential components of stress can be reduced to three components. **(10)**

(b) Show that the torsion problem of cylindrical bar with elliptical cross section under uniform torsion, T can be solved by the wraping function: **(25)**

$$\psi=\frac{b^2-a^2}{b^2+a^2}xy$$

Determine the (i) stresses and (ii) wraping displacement within the cylinder.

L-4/T-1/ME **Date : 16/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **ME 445** (Noise and Vibration)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

Symbols and abbreviations have their usual meaning and interpretation. Assume reasonably any missing data. Short list of formulae is attached.

1. (a) With necessary sketches briefly explain why noise mapping is necessary for a real sound field. **(5)**

(b) Three sound sources #1, #2 and #3 radiate sound at different frequencies that reaches a receiver (R) 1(b) as shown in the Figure for Q 1(b). Given, #1 is a point source, #2 is a cylindrical/line source, and #3 is a plane wave source. Given, SPL at a point A is 95 dB and at a point B is 80 dB. Power of source #3 is 105dB. Absorption coefficient $\alpha = 0.10$ dB/m. **(30)**

Given, distances: #1 to R = 60m, #2 to R = 30m, #3 to R = 60m, #1 to A = 9m, #2 to B = 14m.

Calculate: (i) spread out loss and absorption loss in each case and (ii) hence SPL at R. (iii) p_{rms}, acoustic energy density and particle displacement amplitude X at R.

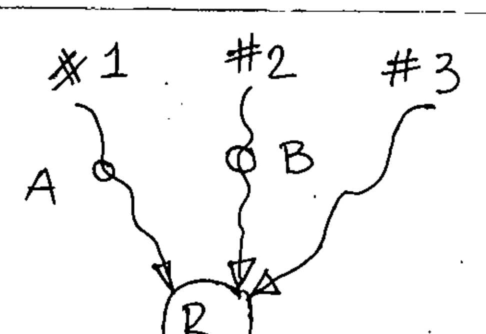


FIG. for Q.1(b)

2. (a) Suppose there is a sound source of variable frequency at your left so that at 1 kHz your left ear senses 100 dB (SPL) but the right ear senses 90 dB (SPL). With necessary sketches and plots, explain what would be the possible changes in SPL at left and right ears as frequency gradually increases. **(10)**

(b) A heavy-duty engine is to be installed in the machine room of an industry. Describe with necessary sketches, the step-by-step procedure for such an installation as far as noise and vibration control is concerned. **(15)**

(c) If an audio signal has 1/3rd octave band at a central frequency of 1.2 kHz and PBL of 105 dB, find PSL (f_c) and Sp (f_c), Take, $S_{ref} = 4 \times 10^{-10}$ Pa^2/Hz. **(10)**

Contd P/2

3. (a) A factory room has a dimension of 10m × 15m × 7m. The absorption coefficients for floor, ceiling and walls are 0.1, 0.12 and 0.11 respectively. Calculate (i) average absorption coefficient and RT at 1 kHz. (ii) A m/c is turned on and at a distance of 3 m from the m/c a worker receives an SPL of 90 dB. If the directivity factor at the worker's position is 2.7, find the sources power in Watt. **(15)**

(b) Specify the required boundary conditions for a hinged free beam. Hence, derive the characteristic equation. **(15)**

(c) Neatly sketch and label (i) a standard acoustic barrier (ii) a reactive silencer. **(5)**

4. Original governing equation of axial vibration of a rod is given as follows, **(10)**

$$EA\frac{\partial^2 u}{\partial x^2} = m\frac{\partial u^2}{\partial t^2} \quad \text{(m = mass per unit length)}$$

Find the group speed and phase speed and hence determine whether the stress wave is dispersive in the rods.

(b) Define stationary random vibration.

What are the criteria for determining the type of random vibration in terms of $\mathbf{N_0}$ (the number of zero crossings) and **2M** (the number of positive and negative peaks)? **(10)**

(c) A random signal has a spectral density S(f) that varies linearly between 20 and 1200 Hz and is zero outside this frequency range. S(f) is 0.014 cm^2/Hz at 20 Hz and 0.016 cm^2/Hz at 1200 Hz. Its mean value is 3 cm. **(15)**

(i) Determine its rms value, standard deviation and power spectrum G (f).

(ii) Maximum and minimum value of x.

Assume Normal distribution and, Natural spread = 6 times standard deviation.

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) A cylinder of mass, m and mass moment of inertia, J_o is free to roll without slipping, but is restrained by the spring *k*, as shown in Fig. for Q. 5(a). Determine the equation of motions by Lagrange's method and hence find the natural frequency of oscillation of the system. **(15)**

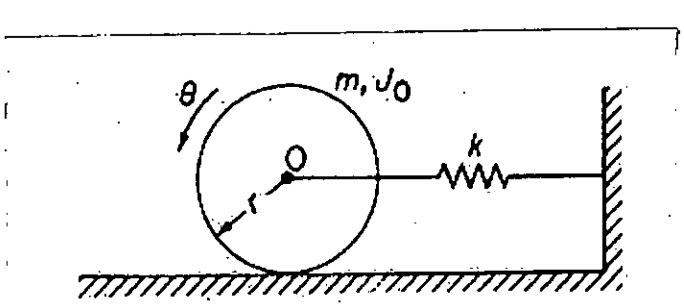


Fig. for Q.5(a)

Contd P/3

ME 445

Contd...Q. No. 5

(b) (i) An rms voltmeter specifies an accuracy of ±0.35 dB. If a vibration of 1.5 mm rms is measured, determine the millimeter accuracy as read by the voltmeter. (ii) Outline the bounds for the following vibration specifications in a plot: Max, acceleration = 5g, max. displacement = 5 mm., min. and max. frequencies: 1 Hz and 100 Hz. **(20)**

6. (a) For rotating unbalance, write down the expression of $\frac{MX}{me}$ in terms of speed ratio (β), and damping ratio (ζ). Prove the $\frac{MX}{me}$ approaches unity for a large value of β (i.e., β >> 1). **(9)**

(b) A machine (m = 50 kg) vibrates 0.003 m under a rotating unbalance (me) for a large value of β. Find, (i) me (ii) X at resonance if ζ = 0.05. **(8)**

(c) A spring-mass system, with m = 100 kg and k = 400 N/m, is subjected to a harmonic force $f(t) = F_0 \cos\omega t$ with F_0 = 10 N. Find the response of the system when ω is equal to (i) 2 rad/s, (ii) 0.2 rad/s, and (iii) 20 rad/s. Discuss the results. **(18)**

7. (a) For a SDOF system, having harmonically excited vibrations, following data are given: m = 150 kg, k =2 MN/m, damping ratio, ζ = 0.5. Draw the system, mechanical impedance diagram, and write the governing equation. Find magnitude of the impressed force if X = 0.01 m at ω = 600 rpm. Also find the transmitted force. Draw TR versus β curve to show its importance in vibration isolation. **(17)**

(b) With sketches, define a tuned dynamic vibration absorber. What is its limitation? **(6)**

(c) An engine weighing 10 kg vibrates violently when runs at a speed of 4000 rpm. A tuned absorber of 2 kg is attached to make its vibration zero. Find the magnitude of the impressed force if absorber's amplitude is 0.01 m. Also plot the engine amplitude-speed curve. **(12)**

8. (a) With sketches, describe the working principle of a Houdaille damper. Write down the governing equations for this damper. Also plot its response vs. speed ratio curve and hence define the term 'optimum damping ratio'. **(14)**

(b) Distinguish between a seismometer and an accelerometer. **(6)**

(c) Given, for the system shown in Fig. for Q. 8(c), m_1 =1 kg, m_2 = 2 kg, k_1 = 100 N/m, k_2 = 90 N/m. Find: **(15)**

(i) Equation of motion by Lagrange's method.

(ii) Resonant frequencies.

Contd P/4

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Contd…Q. No. 8(C)

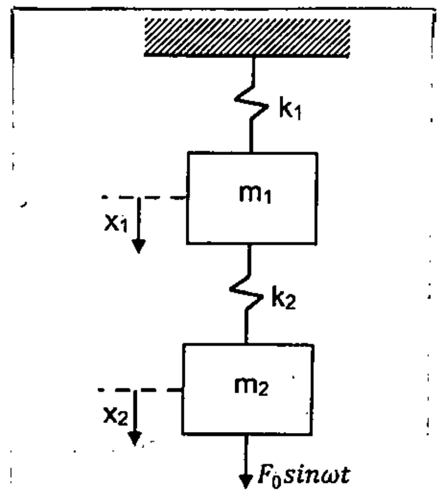

Fig. for Q.8(c)

ME445 Short list of formulae

$H(\omega) = \frac{\bar{X}}{F_0} = \frac{1/k}{1-(\omega/\omega_n)^2 + i2\zeta\omega/\omega_n}$	$\frac{M}{m}\frac{X}{e} = \frac{\left(\frac{\omega}{\omega_n}\right)^2}{\sqrt{\left[1-\left(\frac{\omega}{\omega_n}\right)^2\right]^2 + \left[2\zeta\frac{\omega}{\omega_n}\right]^2}}$
$\tan\phi = \frac{2\zeta\left(\frac{\omega}{\omega_n}\right)}{1-\left(\frac{\omega}{\omega_n}\right)^2}$	$TR = \left\|\frac{F_T}{F_0}\right\| = \sqrt{\frac{1+(2\zeta\omega/\omega_n)^2}{\left[1-(\omega/\omega_n)^2\right]^2 + [2\zeta\omega/\omega_n]^2}}$
$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_i}\right) - \frac{\partial T}{\partial q_i} + \frac{\partial U}{\partial q_i} = Q_i$	$(m_1 m_2)\omega^4 - \{(k_1+k_2)m_2 + (k_2+k_3)m_1\}\omega^2 + \{(k_1+k_2)(k_2+k_3) - k_2^2\} = 0$
$R = \frac{1}{2}\dot{x}^T[c]\dot{x}$	$\lambda^2 - \left(\frac{k_1+k_2}{m_1} + \frac{k_2+k_3}{m_2}\right)\lambda + \frac{k_1k_2+k_2k_3+k_3k_1}{m_1m_2} = 0$
$\frac{\partial R}{\partial \dot{x}_i}$	$\omega_n = n\sqrt{\frac{R}{r}}$
$\left\|\frac{K\theta_n}{M_0}\right\| = \sqrt{\frac{\mu^2(\omega/\omega_n)^2 + 4\zeta^2}{\mu^2(\omega/\omega_n)^2(1-\omega^2/\omega_n^2)^2 + 4\zeta^2\left[\mu(\omega/\omega_n)^2 - (1-\omega^2/\omega_n^2)\right]^2}}$	$T = -m(R+r)n^2R\phi$
$f_u = 2^n f_l$ and central frequency, $f_c = \sqrt{f_l f_u}$	$J_{eff} = -\frac{m(R+r)^2}{1-r\omega^2/Rn^2}$
Acoustic impedance = ρc = 406 rayls	Pressure amplitude, $P = \omega X \rho c = 2\pi f X \rho c$
$\bar{\varepsilon} = I/c$	*Pressure band level = 20 log $_{10}$ p_{band}/p_{ref}*
RT = 0.161 V/A $A = \bar{\alpha} S = \sum \alpha_i S_i$	Pressure spectral level, PSL (f) = 10 $\log_{10}$ [S_p (f) /S_{ref}]
$L_p = L_W + 10\log_{10}(Q_\theta/4\pi r^2 + 4/\bar{\alpha}S)$	$N_F = (D_1 + D_2 - S)/(\lambda/2)$ IL = 16 + 10 log N_F

L-4/T-1/ME Date: 16/10/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **ME 467** (Automobile Engineering)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

Abbreviations and Symbols have their usual meaning.

1. (a) What is a STAP? How does it improve the performance of a retrofitted CNG vehicle? **(11)**

   (b) A CNG cylinder is specified as – Type-II, 60L and fitted with TRD. What do you understand from the specification? **(6)**

   (c) What do you understand by "Single Wire Configuration" for an automobile? Why is it used? **(6)**

   (d) Briefly explain how a car AC system responses to the variable cooling load requirements? **(12)**

2. (a) Distinguish between BEV and HEV. Briefly discuss the factors that influence whether a BEV generates less environmental pollution compared to equivalent ICEV. **(14)**

   (b) Identify the symbols used in car dashboard for – Brake, Charging and MIL. **(6)**

   (c) What do you understand by SRS airbag? Briefly explain how it functions to protect a driver in an accident. **(15)**

3. (a) An automotive tyre is specified as – 185/70 R 15 S TWI. What do you understand from this specification? **(6)**

   (b) Briefly discuss the advantages of using a Radial Phy Tubeless Tyre. **(12)**

   (c) How does the ECU knows about the engine speed? Briefly explain how the sensor concerned operates. **(11)**

   (d) Distinguish between the "registration number" and "identification number" of a vehicle. **(6)**

4. (a) Why does a driver needs to keep on pressing the accelerator pedal even once a desired speed is achieved? Which parameters dictate how fast the vehicle can accelerate to a desired speed? **(12)**

   (b) Which type of body movement is experienced when a vehicle brakes? From mechanics view point show and explain why it happens. **(11)**

   (c) Which type of starting motor is most commonly used in modern automobiles? Briefly explain the role of the "Overrunning Clutch" for the protection of an automotive starter motor. **(12)**

Contd P/2

ME 467

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.
Assume any data if necessary. Symbols used to have their usual meaning.

5. (a) Using block diagrams show how power flows from the engine flywheel to the vehicle wheels in case of (i) a manual transmission FWD and (ii) an automatic transmission 4WD vehicles. **(12)**

   (b) Explain how the propeller shaft of a RWD vehicle adjusts itself to the changes in the length and angle of power transmission (to the rear axle) due to the road bumps and holes. **(6)**

   (c) What are the functions of a clutch in manual transmission? What is axle ratio? **(8)**

   (d) Illustrate the differences between the type of gearbox used in manual transmission and in automatic transmission. **(9)**

6. (a) List the major components of manual and power steering systems. **(5)**

   (b) What are the gear ratios used in a typical steering system? How do they affect the steering effort? **(5)**

   (c) Describe the working mechanism of 'recirculating ball steering system'. **(12)**

   (d) State briefly the significance of the following geometrical parameters of an automobile: **(13)**

   (i) wheel-base, (ii) turning radius, (iii) camber, (iv) caster

7. (a) What are the 'vehicle factors' that influence the typical stopping distance of a vehicle during braking? **(4)**

   (b) Differentiate between disc brakes and drum brakes mentioning their construction, effectiveness of braking, cost and maintenance. **(12)**

   (c) Draw the layout of a dual-circuit hydraulic braking lines of a vehicle having disc brakes at the front and drum brakes at the rear. **(9)**

   (d) With a schematic describe how a vacuum-assisted braking system works. **(10)**

8. (a) What are the functions of a suspension system in a vehicle? **(6)**

   (b) List different arrangements of front and rear suspension systems in a vehicle with their relative merits and demerits. **(12)**

   (c) Explain how 'sprung weight' and 'unsprung weight' of a vehicle effect its stability and comfort during rides on the road. **(9)**

   (d) Illustrate how a telescopic shock-absorber works. **(8)**

L-4/T-1/ME **Date : 01/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **IPE 431** (Machine Tools)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Why do leadscrew and feedrod keep on rotating even when they are not engaged with the carriage? **(5)**

   (b) Is there any common speed values between the short and long gear train of the model 16k20 engine lathe machine? Answer with necessary equations and show the calculations. Refer to Figure Q. 1(b). **(20)**

   (c) Write down the methods for taper turning using an engine lathe machine. Explain the method with the help of Figure Q 1(c). **(10)**

2. (a) What is involute profile? Explain in brief. How is involute profile generated in the gear shaper machine? **(10)**

   (b) What are the applications of internal and external steps found in the jaws of a 3 jaw self-centering chuck? **(5)**

   (c) Select the differential change gears and determine the number of revolutions of index crank for cutting a gear with 63 teeth. Gears are available with teeth number 11, 13, 39, 53, 71, 81, 105, 109, 111, 171. Index plates are available with hole number 33, 49, 70, 88, 95 and 120. **(12)**

   (d) Name the components identified in the Figure Q. 2(d) and describe the motion transfer in the case of differential indexing using the same figure. **(8)**

3. (a) "Gear shaper machine has an additional 6th motion for cutting helical gear."-Explain. **(6)**

   (b) With necessary diagram, explain the motion transfer from hob to the gear blank in the case of a gear hobber. **(8)**

   (c) "In case of cutting spur gears, the hob is set at an angle which is different from when cutting helical gears." – Explain with necessary equations. **(6)**

   (d) Generate the equation for the feed movement gear train starting from spindle revolution to the carriage via feedrod. **(15)**

4. (a) With necessary sketch, describe the main components and their functions in a shaper machine. **(10)**

   (b) "The Generatrix and Directrix can be obtained in four ways." - Explain with necessary diagrams. **(15)**

   (c) Providing necessary sketches, describe tool-work motions, generatrix and directrix in the case of following machining operations: (i) External threading (ii) Internal grooving **(10)**

Contd P/2

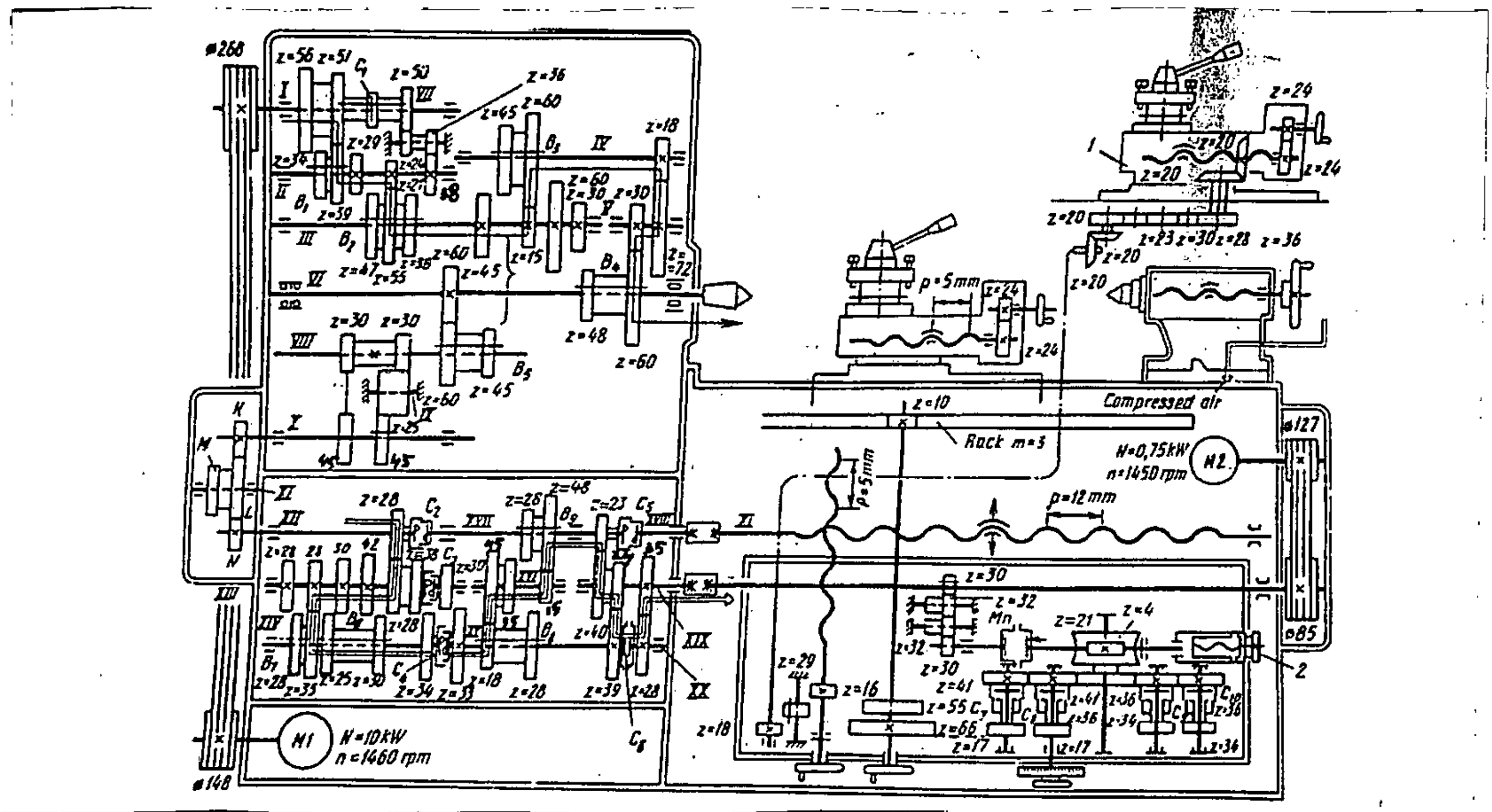

Figure Q-1(b)

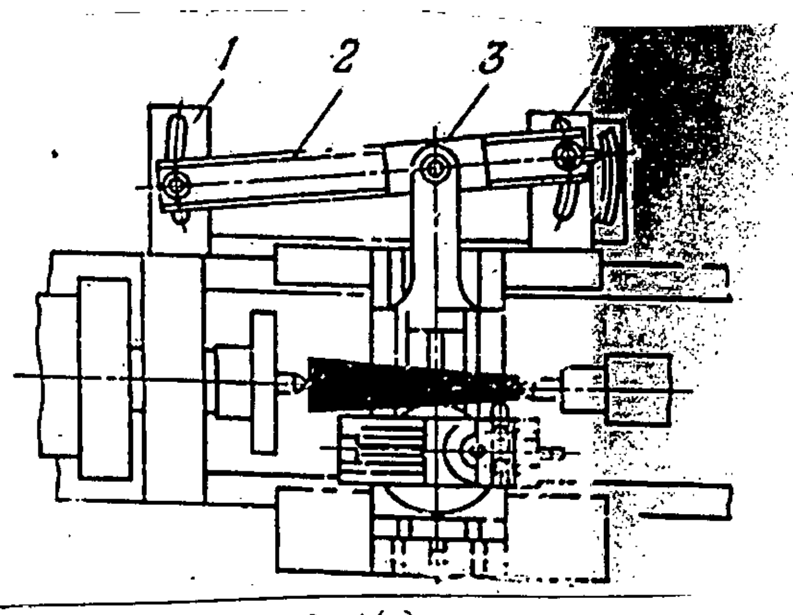

Figure Q-1(c)

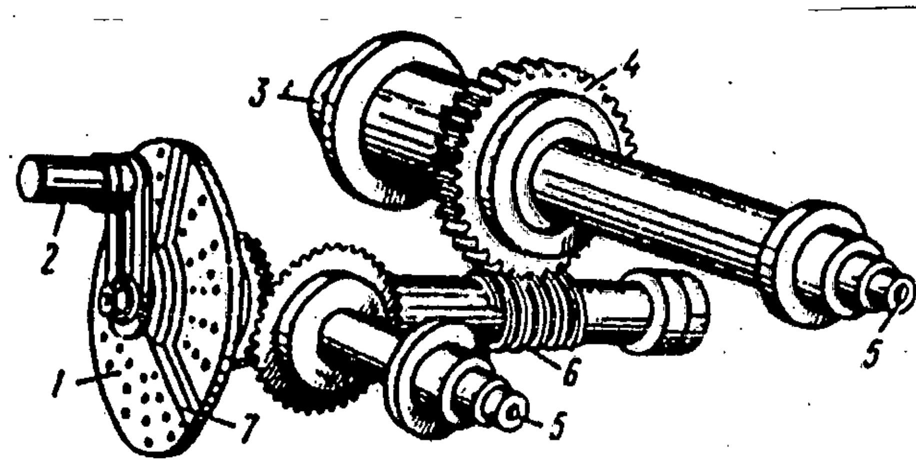

Figure Q-2(d)