L-4/T-1/ME

Date : 16/07/2016

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA


Sub : **ME 401** (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**.

Assume reasonable values for missing data (if any).

Symbols have their usual meanings.

1. (a) An engine with an indicated thermal efficiency of 25% and mechanical efficiency of 75% consumes 25 kg/hr of fuel at a fixed speed. The bmep is 5 bar and the mean piston speed is 15 m/s. Assuming it to be a single cylinder square engine, determine the crank radius and the speed in revolutions per minute. Take the heating value of fuel as 42 MJ/kg.

(b) What is piston slap and what are its effects on the engine? Describe with a neat sketch, how piston slap can be minimized.

(c) Discuss in detail the improvements made on pistons and piston rings of IC engines over the last five decades.

2. (a) What is scavenging? Why is scavenging necessary in two-stroke cycle engines? With neat sketches, distinguish between the various types of scavenging.

(b) Make a comparison between DI and IDI diesel engines.

(c) Draw the value-timing diagram of an SI engine and discuss the valve opening, closing, and overlapping on engine performance.

3. (a) Explain why an idling SI engine requires a rich mixture of fuel and air. How is mixture richness achieved in the case of (i) carburettor, (ii) EFI system?

(b) Discuss the mechanics of HC formation in SI and CI engines.

(c) Name different types of fuel supply/metering systems of CI engines and list their merits and demerits.

4. (a) Name the various types of gas turbine combustors. Describe, with neat sketch(es), the construction and operation of a GT combustor.

(b) Describe in detail, the working principle of the various equipment used for exhaust gas after treatment used in modern CI engines.

(c) Define and explain extended Zeldovitch Mechanism.

Contd .......... P/2
ME 401

SECTION – B

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

5. (a) Classify flames. (5)
   (b) Give physical interpretation of 'burning velocity' and 'flame speed'. (10)
   (c) Briefly explain the phases of SI engine combustion. Explain how these phases are accommodated in engine combustion modeling. (10)
   (d) Why does spark timing needs to be advanced more (i) for lean mixture, (ii) at high engine speed. (10)

6. (a) Explain the 3 zones of gas turbine combustion. (5)
   (b) Make a brief comparison between SI engine and CI engine knock. (10)
   (c) Explain the characteristics of CI engine fuels. (10)
   (d) Would a high octane fuel have good knock resistance in diesel engine? Explain. (10)

7. (a) Define volumetric efficiency. (5)
   (b) Briefly explain the procedure to size the intake and exhaust valves. Explain why exhaust valves are smaller in size. (10)
   (c) Briefly explain the 'similitude' principle used in engine design. Explain how some of the parameters like inlet charge temperature, coolant temperatures are accommodated in the estimation of volumetric efficiency. (10)
   (d) If an engine has a bore of 0.1 m, stroke of 0.1 m, inlet flow effective area of 4.0x10^-4 m² and inlet air temperature of 330 K, what is the maximum engine speed while maintaining good volumetric efficiency? (10)

8. (a) What are the basic requirements of a dynamometer? (5)
   (b) Mention some of the key characteristics of different types of dynamometers. (10)
   (c) For engines, show that
   \[ \text{bmep} = \eta_i \eta_{\text{comb}} \eta_m \eta_v \left( P_i \frac{P_i}{A} \cdot Q_{\text{LHV}} \right) \]
   what is the maximum value of bmep for iso-octane? (10)
   (d) Make some key observations from the performance maps of SI and CI engines (Fig. for Q. 8(d)). (10)
1. (a) Using impulse and momentum principle, derive an expression of efficiency for a series of moving vanes fitted on the circumference of a wheel. Show the condition for maximum efficiency.

(b) A jet of water of 10 mm diameter strikes at the center of a fixed curved blade. The jet is deflected through an angle of 160°. If the water flow rate is 2.7 l/s and the force acting along the direction of jet is 150 N, find the ratio of actual force and theoretical force acting on the blade. Also calculate the force normal to the direction of jet acting on the blade and the ratio of velocities of water at outlet and inlet.

2. (a) Describe the functions of major components of a Pelton turbine. Write the impact of exit angle of the bucket in Pelton turbine.

(b) With necessary sketches describe the working principle of Servo motor control mechanism used for Pelton wheel.

(c) A Pelton wheel is rotating at a speed of 600 rpm. The diameter of jet is 80 mm and the jet velocity is 110 m/s. The ratio of jet to bucket speed is 2.2. The bucket deflects the jet through an angle of 165°. Find the (i) wheel diameter, (ii) power developed, and (iii) loss of energy at the exit of water.

3. (a) What is the physical significance of specific speed of a turbine? Derive the expression of it.

(b) An inward flow reaction turbine develops 220 kW at 300 rpm under a head of 20 m. The inlet and outlet diameters of the turbine are 2 m and 1 m, respectively. The width of the wheel at inlet is 0.2 m and the flow rate of water is 1.6 m³/s. The velocity of flow at outlet is 3 m/s and the discharge is radial. Find the hydraulic efficiency, overall efficiency, vane angles and guide vane angle at inlet.
4. (a) What is fluid coupling? Describe the working principle of it with neat sketches. (12)
(b) Explain the performance of a torque converter with graph and point out the differences with fluid coupling. (8)
(c) A propeller turbine develops 7 MW under a head of 5 m. The speed ratio is 2 and the flow ratio is 0.65. The diameter of the boss is 0.36 times the external diameter and the overall efficiency is 90%. Find the diameter of the runner, speed and specific speed of the turbine. (15)

SECTION – B
There are FOUR questions in this section. Answer any THREE. The questions are of equal value.

5. (a) Describe the functions and working principle of air vessels in a reciprocating pump. (b) A single acting reciprocating pump has a piston of diameter 75 mm and a stroke of 150 mm. It draws water from a sump 3.5 m below the pump through a pipe of 5 m long. If separation occurs at 78.46 kPa below atmospheric pressure when the pump runs at 45 rpm, find the diameter of suction pipe for no separation. Assume simple harmonic motion of the piston.

6. (a) Explain indicator diagram of a reciprocating pump. What is separation in a reciprocating pump? (b) A centrifugal pump delivers 10 l/s at 900 rpm against a head of 20 m. What head will be developed and what will be the quantity of water delivered when the pump runs at 600 rpm?

7. (a) Explain cavitation in a centrifugal pump. With the help of a neat sketch discuss the different heads and main components of a centrifugal pump. (b) A centrifugal pump delivers 45 l/s of water through a 100 m long and 100 mm diameter pipe to a total height of 22 m. If the overall efficiency is 82%, find the power required to drive the pump. Take $f = 0.04$ for the pipe. Consider velocity head for the whole pipe system.

8. (a) Describe the different criteria for the selection of centrifugal pump. (b) A centrifugal pump delivers 130 l/s of water at 1050 rpm. The outside diameter of impeller is 300 mm and it is 65 mm wide at exit. The blade angle at outlet is 30°. If the manometric efficiency is 86%, find the specific speed of the pump.
L-4/T-l/ME

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA


Sub: IPE 431 (Machine Tools)

Date: 26/07/2016

Full Marks: 210

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) Draw the saw diagrams for AP, GP and LP series. Which one is the best among these three series and why? (5)

(b) Prove that, for a given design horsepower, volume of a gear box is directly proportional to the number of teeth and inversely proportional to the speed. Also prove that, if module is constant, kinetic energy is proportional to the cube diameter and directly proportional to the speed. (20)

(c) For a radial piston pump, bore diameter of cylinder is 0.5 m, stroke length of the piston is 10 cm, number of pistons is 12, rotor speed is 450 r.p.m. Calculate the supply rate of radial piston pump. (10)

2. (a) What are the requirements of a Machine Tool? (5)

(b) Write down the structural formula for \( Z = 18 \). Draw four ray diagrams for \( Z = 18 \). Also calculate the speeds, if input speed is 1200 rpm and \( \varphi = 1.41 \). (16)

(c) What do you understand by formative capacity? Show that, maximum relative loss of formative capacity remains constant for geometric progression series. (10)

(d) Prove that the difference in the number of teeth of adjacent gears of a cluster must be at least 4. (Assume that all gears have the same module). (4)

3. (a) How do you modify the following design as shown in Fig. 3(a) for clearance adjustment in dovetail slideways? Write down the reasons behind your modification. (10)

(b) With a neat sketch give a brief description, how a vane pump of external supply type works. What is the effect in supply rate if your change the eccentricity of the housing? (15)

(c) How can you increase the speed of return stroke during the operation of a hydraulic cylinder? (10)

4. (a) With neat sketches, show the cross-sectional view of surrounding and surrounded type flat, vee, dovetail and cylindrical type slideways. (8)

(b) Briefly explain how a hydraulic tracer control unit works. (15)

(c) What are the challenges those create the need for NC machine tools? (12)

Contd ........... P/2
5. (a) Engine lathes is the most commonly used machine tool in typical workshops. Explain why. (10)

(b) With the help of kinematic diagram shown in Fig. for Q. 5(b), discuss the mechanism for cutting metric and inch thread using the lathe machine. Provide necessary kinematic equations for this purpose. (25)

6. (a) Classify milling machines. Briefly explain various external and internal surfaces produced by milling machine. Provide neat sketches with tool position for each of them. (10)

(b) Suppose you have to cut a helical gear using a universal knee and column type milling machine. If number of teeth of the gear is 37 and helix angle is 30°, explain the procedure for indexing and setting table for the helical grooves. Assume a common dividing head is attached with the machine. (25)

7. (a) Taper turning is one of the important applications of engine lathes. Briefly discuss different methods for turning taper using lathe machines. (15)

(b) What are the main specifications of a typical universal knee and column type milling machine? Give typical values for each of these specifications. (7)

(c) What are the movements available in a universal knee and column type milling machine? With the help of kinematic diagram shown in Fig. for Q. 7(c), explain these movements. Also provide kinematic equations for them with maximum and minimum values. (13)

8. Write short notes on the following: (35)

(a) Machine tool tests and accuracy checking

(b) Gear shapering machine

(c) Functions of hydraulic drive in cylindrical grinding machine
Kinematic diagram of model 16K20 engine lathe:
1 - power-driven top slide; 2 - feed-thrust adjustment nut

N = 7.5 kW  
_n = 1450 rpm

Fig: 2.1(a)

Kinematic diagram of model 6P82 universal knee-type milling machine

N = 0.75 kW  
_g = 1450 rpm

Fig: 2.5(b)

Kinematic diagram of model 6P82 universal knee-type milling machine

N = 7.2 kW  
_g = 1450 rpm

Fig: 2.7(c)
1. (a) What are the modifications that are introduced in reversed Carnot cycle to convert it in ideal vapor compression refrigeration cycle and why? Show these processes on P-h and T-s diagrams.
(b) Calculate the power required by the two compressors in a R134a system which serves a 60 TR evaporator at −10°C and 70 TR evaporator at 0°C. The system uses two stage compression with inter-cooling and is arranged as in Fig. for Q. No. 1(b). The condensing temperature is 32°C. Also calculate the COP of the system.

2. (a) Air enters a 30-cm-diameter cooling section at 1 atm, 35°C, and 60 percent relative humidity at 120 m/min as shown in Fig. for Q. No. 2(a). The air is cooled by passing it over a cooling coil through which cold water flows. The water experiences a temperature rise of 8°C. The air leaves the cooling section saturated at 20°C. Determine (i) the rate of heat transfer, (ii) the mass flow rate of the water, and (iii) the exit velocity of the airstream.
3. (a) An air conditioner supplies air to three rooms in a small office premises. The schematic layout of the duct system and the volume flow rate of each room is shown in Fig. for Q. No. 3(a). The length of each duct-segment is tabulated in Table. (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 and indicate the amount of dampering in the other branches to balance the flow. Consider a pressure drop of 25 Pa at each of the outlet grilles at D, E and F. In the calculation, consider the resistance due to the elbow and Tee as 10 Pa and 15 Pa respectively.

(b) Draw the schematic diagram of a typical central air conditioning system.

(b) Classify fire according to NFPA and specify which type of extinguisher will be used for different type of fire.

(c) Draw the typical diagram for fire protection system with ground tank and automatic fire pump (according to BNBC).

Contd ............ P/3
4. (a) What are the requirements for the ideal performance of passenger elevators?

(b) For an office building, downtown, diversified use, 15 rentable floors above the lobby, each 1500 m² net. Floor-to-floor height = 3.7 m, determine a workable elevator system arrangement.

(c) For an escalator of 35° incline, two passenger per step, speed of 0.5 m/s and 500 mm tread or step length, determine the number of persons moved per hour.

SECTION - B

There are FOUR questions in this section. Answer any THREE.
Refrigeration and A/C Data book will be provided.

5. (a) Classify different types of compressors used in refrigeration systems and hence briefly describe the working principle of a screw compressor.

(b) Describe with neat sketches counter-flow forced draft evaporative condenser.

(c) What are the different devices used for the control of refrigerant flow? Hence, describe an automatic expansion valve with neat sketch.

6. (a) Describe with neat sketches a flooded evaporator used in refrigeration system. In the context of heat transfer, how does it provide better performance?

(b) Describe with proper sketches the liquification process of natural gas by cascade refrigeration.

7. (a) The operating temperatures of a lithium bromide-water absorption system are as: Generator 100°C, condenser 35°C, evaporator 5°C, absorber 30°C. Draw the schematic/block diagram of the system and calculate the followings:

   (i) The heat supplied to the generator.
   (ii) The heat rejected at the condenser and absorber.
   (iii) The cooling effect produced by the evaporator.
   (iv) The coefficient of performance of the cycle.

The mass flow rate delivered by the aqua pump is 0.4 kg/s.

(b) Why are low compression ratio and high suction gas density required for a refrigerant? Explain your answer.

Contd .............. P/4
8. Estimate the cooling load of an office room at 4:00 pm for the following conditions:

Location : Chittagong
Date : 15 May
Floor : 10 m × 10 m, Height = 3 m
Roof : Type 4, 100 mm concrete with 50 mm insulation
Walls : 101 mm face brick + 101 mm common brick (Type D)
Window : 15% of considered wall area, 13 mm clear glass,
U = 2.5 W/m² °C
Lights : 15 W/m², fluorescent bulb
6 people using 3 computers @ 80 W
Assume negligible heat transfer through south and east walls. Also assume ASHRAE standard in door design conditions and ventilation air supply.

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### T1: Recommended Elevator Intervals & Waiting Times

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Interval (sec)</th>
<th>Waiting Time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OFFICE BUILDINGS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent service</td>
<td>15-24</td>
<td>9-14</td>
</tr>
<tr>
<td>Good service</td>
<td>15-29</td>
<td>15-17</td>
</tr>
<tr>
<td>Fair service</td>
<td>30-39</td>
<td>18-23</td>
</tr>
<tr>
<td>Poor service</td>
<td>40-49</td>
<td>24-29</td>
</tr>
<tr>
<td>Unsatisfactory</td>
<td>50+</td>
<td>30+</td>
</tr>
<tr>
<td><strong>RESIDENTIAL</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prestige apartments</td>
<td>50-70</td>
<td>30-42</td>
</tr>
<tr>
<td>Middle-income apartments</td>
<td>60-80</td>
<td>36-48</td>
</tr>
<tr>
<td>Low-income apartments</td>
<td>80-120</td>
<td>48-72</td>
</tr>
<tr>
<td>Dormitories</td>
<td>30-50</td>
<td>18-30</td>
</tr>
<tr>
<td>Hotels—first quality</td>
<td>50-70</td>
<td>30-42</td>
</tr>
<tr>
<td>Hotels—second quality</td>
<td></td>
<td></td>
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</table>

### T2: Minimum PHC

<table>
<thead>
<tr>
<th>Facility</th>
<th>Percent of Population to Be Carried in 5 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OFFICE BUILDINGS</strong></td>
<td></td>
</tr>
<tr>
<td>Center city</td>
<td>12-14</td>
</tr>
<tr>
<td>Investment</td>
<td>11.5-13</td>
</tr>
<tr>
<td>Single-purpose</td>
<td>14-16</td>
</tr>
<tr>
<td><strong>RESIDENTIAL</strong></td>
<td></td>
</tr>
<tr>
<td>Prestige</td>
<td>5-7</td>
</tr>
<tr>
<td>Other</td>
<td>6-8</td>
</tr>
<tr>
<td>Dormitories</td>
<td>10-11</td>
</tr>
<tr>
<td>Hotels—first quality</td>
<td>12-15</td>
</tr>
<tr>
<td>Hotels—second quality</td>
<td>10-12</td>
</tr>
</tbody>
</table>

### T3: Car Passenger Capacity (p)

<table>
<thead>
<tr>
<th>Elevator Capacity (lb)</th>
<th>Normal Passenger Load (per Trip)</th>
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<tbody>
<tr>
<td></td>
<td>2000 (907)</td>
</tr>
<tr>
<td></td>
<td>2500 (1134)</td>
</tr>
<tr>
<td></td>
<td>3000 (1361)</td>
</tr>
<tr>
<td></td>
<td>3500 (1588)</td>
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<tr>
<td></td>
<td>4000 (1814)</td>
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### T4: Elevator Equipment Recommendations

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Elevator Capacity (lb)</th>
<th>Minimum ft/Min.</th>
<th>Minimum mph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office building</td>
<td>2500</td>
<td>0-125</td>
<td>0-40</td>
</tr>
<tr>
<td></td>
<td>3000</td>
<td>126-225</td>
<td>41-70</td>
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<tr>
<td></td>
<td>3500</td>
<td>226-275</td>
<td>71-85</td>
</tr>
<tr>
<td></td>
<td>4000</td>
<td>276-375</td>
<td>86-115</td>
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<tr>
<td></td>
<td>4500</td>
<td>300-400</td>
<td>1000</td>
</tr>
<tr>
<td>Hotel</td>
<td>2500</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td></td>
<td>3000</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>Hospital</td>
<td>3500</td>
<td>0-40</td>
<td>0-20</td>
</tr>
<tr>
<td></td>
<td>4000</td>
<td>101-125</td>
<td>31-40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>126-175</td>
<td>41-55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>176-250</td>
<td>56-75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2250</td>
<td>&gt;75</td>
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<tr>
<td>Apartments</td>
<td>2000</td>
<td>0-75</td>
<td>0-25</td>
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<td>2500</td>
<td>76-125</td>
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<td></td>
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<td>126-200</td>
<td>41-60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;200</td>
<td>&gt;60</td>
</tr>
<tr>
<td>Stores</td>
<td>3500</td>
<td>0-100</td>
<td>0-30</td>
</tr>
<tr>
<td></td>
<td>4000</td>
<td>101-150</td>
<td>31-45</td>
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<tr>
<td></td>
<td>5000</td>
<td>151-200</td>
<td>46-60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;200</td>
<td>&gt;60</td>
</tr>
</tbody>
</table>
C1: Average Trip Time (AVRTP)

No. of local floors

Seconds

250 fpm
300 fpm
350 fpm
400 fpm
500 fpm

12' 0" floor to floor 2500-lb car

12' 0" floor to floor 3000-lb car

12' 0" floor to floor 3500-lb car

12' 0" floor to floor 4000-lb car

No. of local floors

5 6 7 8 9 10 11 12 13 14 15 16 17 18

Seconds

65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
T4: Population of Typical Buildings

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Net Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFFICE BUILDINGS</td>
<td>FT2 PER PERSON (M2/PERSON)</td>
</tr>
<tr>
<td>Diversified (multiple tenancy) Normal</td>
<td>110–130 (10–12)</td>
</tr>
<tr>
<td></td>
<td>Prestige</td>
</tr>
<tr>
<td>Single tenancy</td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td>Prestige</td>
</tr>
<tr>
<td>HOTELS</td>
<td>PERSONS PER SLEEPING ROOM</td>
</tr>
<tr>
<td>Normal use</td>
<td>1.3</td>
</tr>
<tr>
<td>Conversions</td>
<td>1.9</td>
</tr>
<tr>
<td>HOSPITALS</td>
<td>VISITORS AND STAFF PER BED²</td>
</tr>
<tr>
<td>General private</td>
<td>3</td>
</tr>
<tr>
<td>General public</td>
<td>3–4</td>
</tr>
<tr>
<td>(large wards)</td>
<td></td>
</tr>
<tr>
<td>APARTMENT HOUSES</td>
<td>PERSONS PER BEDROOM</td>
</tr>
<tr>
<td>High-rental housing</td>
<td>1.5</td>
</tr>
<tr>
<td>Moderate-rental</td>
<td>2.0</td>
</tr>
<tr>
<td>Housing</td>
<td></td>
</tr>
<tr>
<td>Low-cost housing</td>
<td>2.5–3.0</td>
</tr>
</tbody>
</table>

T5: Office Building Occupancy

<table>
<thead>
<tr>
<th>Building Height</th>
<th>Net Usable Area as Percentage of Gross Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–10 floors</td>
<td>Approximately 80%</td>
</tr>
<tr>
<td>0–20 floors</td>
<td>Floors 1–10 approximately 75%</td>
</tr>
<tr>
<td>11–20 approximately 70%</td>
<td></td>
</tr>
<tr>
<td>0–30 floors</td>
<td>Floors 1–10 approximately 70%</td>
</tr>
<tr>
<td>11–20 approximately 75%</td>
<td></td>
</tr>
<tr>
<td>0–40 floors</td>
<td>Floors 1–10 approximately 70%</td>
</tr>
<tr>
<td>11–20 approximately 75%</td>
<td></td>
</tr>
<tr>
<td>21–30 approximately 80%</td>
<td></td>
</tr>
<tr>
<td>21–30 approximately 80%</td>
<td></td>
</tr>
<tr>
<td>31–40 approximately 85%</td>
<td></td>
</tr>
</tbody>
</table>
BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA
Sub: ME 445 (Noise and Vibration)
Full Marks: 210  Time: 3 Hours
The figures in the margin indicate full marks.
Symbols carry their usual meaning. Reasonably assume any missing data.
USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A
There are FOUR questions in this section. Answer any THREE.

1. (a) A point sound source in air radiates power at a frequency of 1.2 kHz. Assume freely
progressive sinusoidal wave without absorption. An observer receives 75 dB at a distance
of 6 m from the source. Calculate: (i) acoustic power of the source. (ii) Sound intensity,
energy density and particle displacement at observer’s position.
Now assume absorption coefficient of air is 0.15 dB/m. Calculate SPL and sound
pressure at a distance of 18 m from the same source. Take \( P_c = 406 \) rayls for air.
(b) What are the sources of noise in an HVAC system? With sketches describe how the
duct noise is attenuated in an HVAC system.
(c) List the sources of noise of a diesel engine generator. Describe the strategy to
attenuate: exhaust noise, cooling fan noise and structural vibration.

2. (a) With sketches describe an acoustic board. What is the mechanism of sound absorption in
the board? The STL of an acoustic barrier is 25 dB. Calculate its mean acoustic impedance.
(b) ‘Common car silencers are of reactive type’ – explain with necessary sketches.
(c) What is the main objective of spectral analysis? The central frequency of an one-third
octave band is 1 kHz. Calculate its frequency band.
(d) List the essential parts of a sound measuring system.

3. (a) Distinguish between an accelerometer and a microphone. Describe a condenser
microphone.
(b) Define following terms with necessary sketches:
(i) mutual conversion of sound and mechanical vibration.
(ii) equal SPL contour of a real sound field.
(iii) reverberation time of an auditorium.
(c) List five adverse effects of noise.
(d) An observer receives sound from three different sources as described below:

<table>
<thead>
<tr>
<th>Sound sources</th>
<th>Frequency</th>
<th>SPL at observer's position</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 kHz</td>
<td>80 dB</td>
</tr>
<tr>
<td>2</td>
<td>1.2 kHz</td>
<td>90 dB</td>
</tr>
<tr>
<td>3</td>
<td>0.95 kHz</td>
<td>95 dB</td>
</tr>
</tbody>
</table>

Calculate the resultant SPL and corresponding sound pressure at observer’s position when
all the three sources are ON.

Contd .......... P/2
4. (a) A heavy duty machine is to be installed. There must be supply, delivery and drain pipes, as well as electric cables. As far as noise and vibration control is concerned describe the standard practice to install the machine with the aid of sketches. (17)

(b) A room (15 × 10 × 2.5 m) has following acoustic data:
\[ \alpha \] (ceiling and floor) = 0.2
\[ \alpha \] (walls) = 0.3
(i) Calculate reverberation time of the room at 1 kHz.
(ii) A fan of acoustic power 0.015 Watt is turned on in the room described above. Calculate at SPL at a distance of 7 m from the source if directivity factor is 3.5.

(c) List requirements of a good auditorium. (4)

SECTION – B
There are FOUR questions in this section. Answer any THREE.

5. (a) A wheel and axle assembly of moment of inertia \( J \) is inclined from the vertical by an angle \( \alpha \) as shown in Figure for Q. No. 5(a). Determine the frequency of oscillation due to a small unbalance weight \( W \) at a distance \( a \) from the axle. (17)

(b) The following parameters are given for the geared shafts having torsional oscillation without damping as shown in Figure for Q. No. 5(b).
- Gear ratio = 3 : 1
- \( K \) of upper shaft = 7 kN-m/radian
- \( K \) of lower shaft = 0.7 kN-m/radian
- \( I \) of engine's rotary parts = 1 kg-m²
- \( I \) of machine's rotary parts = 18 kg-m²
Find (i) Equivalent system, (ii) Governing Equations by Lagrange's Method, (iii) Natural frequencies, (iv) Normal modes corresponding to natural frequencies [Ignore the mass of gears]. (18)

6. (a) For rotating unbalance, write down the expression of \( \frac{MX}{me} \) in terms of speed ratio (\( \beta \)) and damping ratio (\( \xi \)). Prove the \( \frac{MX}{me} \) approaches unity for a large value of \( \beta \) (i.e., \( \beta \gg 1 \)). A machine (\( M = 50 \) kg) vibrates 0.003 m under a rotating unbalance (\( me \)) for a large value of \( \beta \). Find, (i) \( me \) (ii) \( X \) at resonance if \( \xi = 0.05 \). (14)

(b) Mention at least four causes of shaft whirlring. With a sketch, define the term synchronous whirl. Show that for synchronous whirl, \( \theta = \omega t - \phi \). (6)

(c) A shaft having a fixed disc whirls synchronously. The disc mass eccentricity is unknown but it is found that at the resonant speed the position of the disc center from the fixed reference point is 10 mm. Consider damping ratio 0.10. Calculate the position of the disc center from the fixed reference point and the corresponding phase angle for half of the resonant speed. (15)
7. (a) For a SDOF system having harmonically excited vibrations, following data are given:
   \( m = 100 \text{ kg}, \ K = 2 \text{ MN/m}, \) damping ratio = 0.7.
   Draw the system and mechanical impedance diagram. Also, write down the governing equation of the system.
   If \( X = 0.01 \text{ m} \) at \( \omega = 600 \text{ rpm} \), find the magnitude of the impressed force and the transmitted force. Also draw the TR vs. \( \beta \) curve to show where vibration isolation is possible.
   (b) With sketches, define a tuned dynamic vibration absorber. What is its limitation?
   (c) An engine weighing 10 kg runs at 4000 rpm which corresponds to its natural frequency. 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.

8. (a) A cantilever beam is loaded with distributed and concentrated loads as shown in Figure for Q. No. 8(a). Consider the bending stiffness of the beam as \( 10^5 \text{ N-m}^2 \). Using the Dunkarley's formula to find the frequency of natural vibration for this beam.
   (b) Distinguish between a seismometer and an accelerometer. With sketches describe the working principle of a piezocrystal accelerometer.
   (c) 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'.

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Figure for Q. No. 5(a)

Figure for Q. No. 5(b)

Figure for Q. No. 8(a)
SECTION – A

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

Symbols have their usual meaning.

1. (a) Define a thin plate. How does flexural rigidity of a plate differ from that of a beam? (10)
   (b) The lateral deflection of a square plate of sides a, which supports a lateral load represented by the function $q(x, y)$, is given by
   \[ \omega(x, y) = W_0 \cos\left(\frac{\pi x}{a}\right) \cos\left(\frac{3\pi y}{a}\right) \]
   The origin of the coordinate system used coincides with the center of the plate and $W_0$ is the deflection at the center. If the flexural rigidity of the plate is $D$ and Poisson's ratio is $\mu$, determine:
   (i) the loading function $q(x, y)$.
   (ii) the supporting conditions of the plate ends.
   (iii) bending moment at the center of the plate.

2. A thin rectangular plate of dimensions $(a \times b \times h)$ is simply-supported along its edges and carries a uniformly distributed loading of intensity $q_0$. Giving details of Navier's classical solution of thin plate bending, determine the following: (35)
   (i) deflected form of the plate.
   (ii) maximum lateral deflection of the plate.
   (iii) distributions of bending moments.
   (iv) maximum bending moments in the plate.
   (v) distribution of twisting moment.
   (vi) maximum twisting moment in the plate.

3. (a) State and explain the mathematical background of the minimum potential energy method for the problems of solid mechanics. Write an expression for potential energy for a typical beam subjected to all possible types of loading. (18)
   (b) Consider a mechanical system of two metallic bars rigidly fixed at their ends as shown in Fig. for Q3(b).
   Given data: $E_{Al} = 70 \text{ GPa}$, $A_{Al} = 900 \text{ mm}^2$, $L_1 = 200 \text{ mm}$
   $E_{St} = 200 \text{ GPa}$, $A_{St} = 1200 \text{ mm}^2$, $L_2 = 300 \text{ mm}$
   $P = 10,000 \text{ N}$
   Find the displacement at the junction of the two bars using a suitable energy method.

Contd .......... P/2
4. (a) Give a neat sketch of a propped cantilever beam which is resting on an elastic foundation and subjected to a uniformly distributed loading over the full span. Starting from the basic relation between the bending moment and curvature, derive the governing differential equation for the deflection of the above beam.

(b) What do you understand by natural and kinematic boundary conditions? Give the physical and mathematical interpretations of the boundary conditions for the following beams:

Figure for Q4(b)
ME 441

SECTION - B

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

5. (a) Derive the 3-d stress-strain relations in terms of the lame constant \( \lambda \) and shear modulus \( G \). (15)

(b) The displacement field of a deformed elastic body is given by,

\[
\begin{align*}
    u &= (2x + 5xy^2 + 5z) \times 10^{-5} \text{ m} \\
    v &= (3x + 5y) \times 10^{-5} \text{ m} \\
    w &= (xz^2) \times 10^{-5} \text{ m}
\end{align*}
\]

(i) Find the state of strain at point (2, 5, 1) within the body. (20)

(ii) Find the state of stress at the same point if \( G = 80 \text{ GPa} \) and \( \lambda = 115 \text{ GPa} \).

6. (a) Show that the change in the volume of a cube due to a tensile load in the \( x \) direction is given by,

\[
\Delta V = V_0(\varepsilon_x - 2\mu\varepsilon_x)
\]

where the symbols have their usual meanings. (20)

(b) A 1.5 m long rod with a cross-section diameter of 50 mm is subjected to a load of 20 kN in the direction of its length. Find the change in volume of the rod if \( E = 200 \text{ GPa} \). (15)

7. (a) Determine whether the following displacement field represents a feasible deformed state in a solid body

\[
\begin{align*}
    u &= ax^2; \\
    v &= ay; \\
    w &= az
\end{align*}
\]

where \( a \) is a non-zero constant. (20)

(b) Consider the following state of stress and strain

\[
\begin{align*}
    \sigma_{xx} &= x^2; \\
    \sigma_{yy} &= y^2; \\
    \sigma_{zz} &= 0 \\
    \gamma_{xy} &= -2xy; \\
    \gamma_{zz} &= 0
\end{align*}
\]

Find the condition for the above state to be physically possible. (15)

8. (a) Determine the stress distribution in a cylindrical bar of elliptic cross-section, subjected to uniform torque \( T \). (15)

(b) Derive the governing equation for warping function formulation and find an expression for the torsional constant \( J \) in terms of stress functions. (20)
L-4/T-1/ME

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA


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.

The abbreviations have their standard meaning.

1. (a) A tyre is designated as – 185/70 R 14 H with TWI mark. What do you understand from this tyre specification? (7)
   (b) State the advantages of using a tubeless tyre. Briefly explain why they are less prone to puncture during operation. (10)
   (c) At what pressure is CNG filled in cylinders in Bangladesh? Compare its energy storage capacity with respect to typical petrol tank volume. (8)
   (d) What is STAP? How does it improve the performance of a retrofitted CNG vehicle? (10)

2. (a) What is a TXV? Briefly explain its function in a typical automotive air-conditioning system. (10)
   (b) Briefly explain the common methods practiced for refrigerant leakage detection in an automotive air-conditioning circuit. (8)
   (c) What do you understand by a "Maintenance Free Car Battery"? How can we check the charge condition of such a battery? (8)
   (d) Define Ampere-hour capacity of a car battery. An automotive battery is designated as 12 V, 60 plate, 80 A-h – what do you understand from the specification? (9)

3. (a) What is a TPS? How does it influence the operation of an automotive SI engine? (9)
   (b) What do you understand by an OBD system? How is it different from a MIL system shown on the car dash-board? Briefly explain. (11)
   (c) When do we need a "Rear Window Defogger"? Briefly state its working principle. (9)
   (d) List three safety devices typically installed with the fuel system of a CNG vehicle. (6)

4. (a) How is power consumption due to aerodynamic drag on a car evaluated? Briefly discuss the main factors influencing aerodynamic drag on a car. (10)
   (b) What do you understand by a 'Hybrid Vehicle'? Briefly explain its advantages and limitations compared to conventional vehicles. (10)
   (c) What do you understand by "dynamic shift of weight" during – acceleration and braking of a car. Briefly explain how – track width, CG height and vehicle mass influences such shift of forces. (10)
   (d) What do you understand by 3-Box structure of an automotive chassis? Briefly state. (5)

Contd ........... P/2
There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Explain the electric starting system of an automobile engine.  
(b) Discuss the function of an 'over running clutch' in the operation of an electric starter motor.  
(c) How can you Push Start a manual transmission car if it has a weak battery? Can it be done in a car with automatic transmission?  
(d) What do you understand by 'Jump Starting'? Can it be used for vehicles with automatic and manual transmission both?

6. (a) What is 'drivetrain' of a motor vehicle? Explain its functions and components.  
(b) Note down the typical characteristics of the front wheel drivetrain.  
(c) Briefly explain the function of a clutch in a car with manual transmission. Note down the components of the typical clutch.  
(d) With a simple sketch identify the components of an Automatic Transmission (AT) and mention its advantages.

7. (a) Compare 'Rack and Pinion' steering system and 'Pitman Arm' steering system used for vehicle steering.  
(b) What do you understand by 'Power Assisted Steering' and explain briefly how it works?  
(c) What is meant by 'Toe'? Draw figures and explain Toe angle of wheel steering.  
(d) Give two examples where 4-wheel steering of a vehicle is used.

8. (a) What do you mean by skidding of Tyres? Discuss the different groups of the causes of skidding.  
(b) Explain the Braking distance of a motor vehicle and show the probable stopping distances in a graph.  
(c) Why do we need variable damping in a shock absorber? Briefly explain how this is attained in a 'semi-active' suspension system.  
(d) Compare the performance of Disc and Drum brakes.