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Tutorial Sheets Sample

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Tutorial Sheets (with EMD Analysis)**

Mechanical Engineering Department, SKIT, Jaipur

Fluid Mechanics and Machines

Tutorial Sheet 1– Fluid Properties

Ques. 1 Calculate the specific weight. Density and specific gravity of one litre of liquid which weighs 7 N. **(7000N/m^3, 713.5 kg/m^3, 0.7135)[Easy]**

Ques. 2 If the velocity distribution over a plate is given $u = \frac{2}{3}y - y^2$ in which u is the velocity in m/s at a distance y meter above the plat, determine the shear stress atb y=0 and y=0.15m. The dynamic viscosity of fluid as 8.63 poises. **[Moderate]**

(0.5756 N/m^2, 0.3167 N/m^2)

Ques. 3 The dynamic viscosity of oil, used for lubrication between a shaft and sleeve is 6 poise. The shaft is of diameter 0.4 m and rotates at 190 rpm. Calculate the power lost in the bearing for a sleeve length of 90 mm. The thickness of the oil film is 1.5 mm

(716.48 W) [Moderate]

Ques. 4 Determine the bulk modulus of elasticity of a liquid, if the pressure of the liquid is increased from 70N/cm^2 to 130 N/cm^2. The volume of the liquid decreases by 0.15 percent. **(4x10^4 N/cm^2) [Moderate]**

Ques. 5 The pressure outside the droplet of water of diameter 0.04 mm is 10.32 N/cm^2 (atm. Pr.). Calculate the pressure within the droplet if surface tension is given as 0.0725N/m of water. **(11.045 N/cm^2) [Moderate]**

Ques. 6 Calculate the capillarity effect in millimetres in a glass tube of 4mm diameter, when immersed in (i) water, and (ii) mercury. The temperature of the liquid is 20° C and the values of the surface tension of water and mercury at 20° C in contact with air are 0.073575 N/m and 0.51 N/m respectively. The angle of contact for water is zero that for mercury 1.30°. Take density of water at 20° C as equal to 998kg/m^3.

(7.51 mm, -2.46 mm) [Moderate]

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Ques. 7 A 400 mm diameter shaft is rotating at 200rpm in a bearing of length 120 mm. If the thickness of oil film is 1.5 mm and the dynamic viscosity of the oil is 0.7 Ns/m^2, determine:

(i) Torque required to overcome friction in bearing;

(ii) Power utilised in overcoming viscous resistance.

Assume a linear velocity profile. **(58.97 Nm, 1.235kW) [Difficult]**

Ques. 8 A vertical cylinder of diameter 180mm rotates concentrically inside another cylinder of diameter 181.2 mm. Both the cylinders are 300 mm high. The space between the cylinders is filled with a liquid whose viscosity is unknown. Determine the viscosity of the fluid if a torque of 20 Nm is required to rotate the inner cylinder at 120 rpm.

(6.96 poise) [Difficult]

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Fluid Mechanics and Machines

Tutorial Sheet 2– Pressure and its Measurement

Ques. 1 Calculate the pressure due to a column of 0.3 of (a) water, (b) an oil of sp. Gr. 0.8, and (c) mercury. **(0.2943 N/cm^2, 0.2345 N/cm^2, 4.002 N/cm^2) [EASY]**

Ques. 2 An open tank contains water upto a depth of 2m and above it an oil of sp.gr. 0.9 for a depth of 1m. Find the pressure intensity (i) at the interface of the two liquids, and (ii) at the bottom of the tank. **(0.8829 N/cm^2, 2.8449 N/cm^2) [EASY]**

Ques. 3 A simple U tube manometer containing mercury is connected to a pipe in which a fluid of sp. gr. 0.9. The other end of manometer is open to atmosphere.

(i) The centre of pipe is 12 cm below the level of mercury in the right limb. Find the pressure of fluid in the pipe if the difference of mercury level in the two limbs is 20 cm.

(ii) Find the vacuum pressure in the pipe, if the difference in the level of mercury in the two limbs is 40 cm and the height of fluid in the left from the centre of the pipe is 15 cm below. **(2.597N/cm^2, -6690.75 N/cm^2) [MODERATE]**

Ques. 4 A U –tube manometer is used to measure the pressure of water in a pipe line, which is in excess of atmospheric pressure. The right limb of the manometer contains mercury and is open to the atmosphere. The contact between water and mercury occur in the left limb. Determine the pressure of water in the pipe line, if the difference in level of mercury in the limbs of U-tube is 10 cm and the free surface of mercury in the right limb is in the level with centre of the pipe. If the pressure of water in pipe line is reduced to 9810 N/m^2, calculate the new difference in the level of mercury. Sketch the arrangements in both the cases. **(12360.6 N/m^2, 8.016 cm) [MODERATE]**

Ques. 5 A single column manometer is connected to a pipe containing a liquid of sp. gr. 0.9. Find the pressure in the pipe if the area of the reservoir is 100 times the area of the tube for the manometer. Centre of pipe in the left limb is 20 cm above the level of mercury and the level of mercury in the right limb is 20 cm above the centre of pipe.

(5.21 N/cm^2) [MODERATE]

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Ques. 6 **A** differential manometer is connected at the two points A and B of two pipes. The pipe A contains a liquid of sp. gr. = 1.5 while pipe B contains a liquid of sp. gr. = 0.9. The pressure at A and B are 1 kgf/cm^2 and 1.80 kgf/cm^2. The difference between the centre of pipe A and pipe B is 3m and between centre of pipe B and the level of mercury in left limb is 2m. If the level of mercury in left limb is greater than level in right limb, then find the difference in mercury level. **(18.1 cm)** **[DIFFICULT]**

Ques. 7 An inverted U-tube manometer is connected to two horizontal pipes A and B through which water is flowing. The vertical distance between the axes of these pipes is 30 cm. When an oil of sp. gr. 0.8 is used as a gauge fluid, the vertical heights of the water columns in the two limbs of the inverted manometer (when measured from the respective centre lines of the pipes) are to be found same and equal to 35 cm. Determine the difference of pressure between the pipes. **(2354.4 N/m^2) [DIFFICULT]**

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Fluid Mechanics and Machines

Tutorial Sheet 3– Hydrostatic forces and Buoyancy

Ques. 1 Determine the total pressure on a circular plate of diameter 1.5m which is placed vertically in water in such a way that the centre of the plate is 3m below the free surface of water. Find the position of the centre of pressure also.

(52002.81 N, 3.0468m) [EASY]

Ques. 2 A vertical sluice gate is used to cover an opening in a dam. The opening is 2m wide and 1.2m high. On the upstream of the gate, the liquid of sp. gr. 1.45 lies upto a height of 1.5 m above the top of the gate, whereas on the downstream side the water is available upto a height touching the top of the gate. Find the resultant force acting on the gate and the position of the centre of pressure. Find also the force acting horizontally at the top of the gate which is capable of opening it. Assume that the gate is hinged at the bottom.**(57565 N, 0.578 m, 27725.5 N) [MODERATE]**

Ques. 3 (a) A circular plate 3 m diameter is immersed in water in such a way that its greatest and least depths below the free surface are 4m and 1.5m. Determine the total pressure on one face of the plate and position of the centre of pressure.**(190621 N, 2.891 m)**

(b) If in the above problem, the given circular plate is having a concentric circular hole of diameter 1.5m, then calculate the total pressure and position of the centre of pressure on one face of the plate. **(143.018 kN, 2.927 m) [MODERATE]**

Ques. 4 A wooden log of 0.6 m diameter and 5 m length is floating in river water. Find the depth of the wooden log in water when the sp. gr. Of log is 0.7.**(0.395 m)**

[MODERATE]

Ques. 5 Find the density of a metallic body which floats at the interface of mercury of sp.gr. 13.6 and water such that 40% of its volume is submerged in mercury and 60% in water. **(6040 kg/m^3) [DIFFICULT]**

Ques. 6 A block of wood of sp. gr. 0.7 floats in water. Determine the meta-centric height of the block if its size is 2m x 1m x 0.8m. **(0.0288m) [DIFFICULT]**

Ques. 7 A solid cylinder of diameter 4 m has a height of 4 m. Find the meta-centric height of the cylinder if the sp. gr. Of the material of cylinder = 0.6 and it is floating in water with its axis vertical. State whether the equilibrium is stable or unstable.

(-0.3833 m) [DIFFICULT]

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Fluid Mechanics and Machines

Tutorial Sheet 4– Kinematics

Ques. 1 Water flows through a pipe AB 1.2 m diameter at 3 m/s and then passes through a pipe BC 1.5 m diameter. At C, the pipe branches. Branch CD is 0.8 m in diameter and carries 1/3 of the flow in AB. The flow velocity in branch CE is 2.5 m/s. Find the volume rate of flow in AB, the velocity in BC, the velocity in CD and the diameter of CE. **(1.92 m/s, 2.25 m/s, 1.0735m)** **[EASY]**

Ques. 2 The velocity vector in a fluid flow is given. Find the velocity and acceleration of a fluid particle at (2,1,3) at time t=1.

$$\mathbf{V= 4x^3i - 10x^2yj + 2tk}$$

(51.26, 1568.9) **[MODERATE]**

Ques. 3 The velocity potential function (φ) is given by an expression

$$\varphi = -xy^3/3 - x^2 + x^3y/3 + y^2$$

i. Find the velocity components in x and y direction.

ii. Show that φ represents a possible case of flow.

($u = y^2/3 + 2x - x^2y$, $v = xy^2 - x^3/3 - 2y$) **[MODERATE]**

Ques. 4 The velocity components in a two-dimensional flow are given below, show that these components represent a possible case of an irrotational flow.

$$\mathbf{u = y^3/3 + 2x + -x^2y \text{ and } v = xy^2 - 2y - x^3/3}$$

[MODERATE]

Ques. 5 Prove that in case of forced vortex, the rise of liquid level at the ends is equal to the fall of liquid level at the axis of rotation. **[DIFFICULT]**

Ques. 6 Given that

$$\mathbf{U = -4ax\ (x^2 - 3y^2)}$$

$$\mathbf{V = 4ay\ (3x^2 - y^2)}$$

Examine whether these velocity components represent a physically possible two dimensional flow, if so whether the flow is rotational or irrotational ? **[DIFFICULT]**

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Fluid Mechanics and Machines

Tutorial Sheet5 – Dynamics

Ques. 1 A pipe line carrying oil of specific gravity 0.87, changes in diameter from 200 mm diameter at a position A to 500 mm diameter at a position B which is 4 meters at a higher level. If the pressures at A and B are 9.81 N/cm^2 and 5.886 N/cm^2 respectively and the discharge is 200 litre/s. Determine the loss of head and direction of flow. **(2.609 m, A to B) [EASY]**

Ques. 2 An oil of sp. gr. 0.8 is flowing through a Venturimeter having inlet diameters 20 cm and throat diameters 10 cm. The oil-mercury differential manometer shows a reading of 25 cm. Calculate the discharge of oil through the horizontal Venturimeter. Cd = 0.98 **(70.465 litres/s) [EASY]**

Ques. 3 The following data relate to an orifice meter:

Diameter of the pipe = 240 mm

Diameter of the orifice = 120 mm

Sp. Gravity of oil = 0.88

Reading of differential manometer = 400 mm of mercury

Co-efficient of discharge of the meter = 0.65

Determine the rate of flow of oil. **(0.008 m^3/s) [MODERATE]**

Ques. 4 A sub-marine moves horizontally in a sea and has its axis 15 m below the surface of water. A pitot-tube properly placed just in front of the sub-marine and along its axis is connected to the two limbs of U-tube containing mercury. The difference of mercury level is found to be 170 mm. Find the speed of the sub-marine knowing that the sp. Gr. of mercury is 13.6 and that of sea-water is 1.026 with respect to fresh water. **(23.01 km/hr) [MODERATE]**

Ques. 5 In a vertical pipe conveying oil of specific gravity 0.8 two pressure gauges have been installed at A and B where the diameters are 16 cm and 8 cm respectively. A is 2 meter above B. The pressure gauge readings have shown that the pressure at B is greater than at A by 0.981 N/cm^2. Neglecting all losses calculate the flow rate. If the gauges at A and B are replaced by tubes filled with the same liquid and connected to a U-tube containing mercury, calculate the difference of level of mercury in the two limbs of the U-tube. **(0.01989 m^3/s, 4.687 cm) [DIFFICULT]**

Ques. 6 A 45° reducing bend is connected in a pipe line, the diameters at the inlet and outlet of the bend being 600 mm and 300 mm respectively. Find the force exerted by water on the bend if the intensity of pressure at inlet to bend is 8.829 N/cm^2 and rate of flow of water is 600 litres/s.

(20890.9 N) [DIFFICULT]

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Fluid Mechanics and Machines

Tutorial Sheet 6 – Laminar Flow and Turbulent Flow

Ques. 1 An oil of viscosity 9 poise and specific gravity 0.9 is flowing through a horizontal pipe of 60 mm diameter. If the pressure drop in 100 m length of the pipe is 1800 kN/m^2, determine:

(i)	The rate of flow of oil;	**(6.36 lit/s)**
(ii)	The centre-line velocity;	**(4.5 m/s)**
(iii)	The total frictional drag over 100 m length;	**(5.089 kN)**
(iv)	The power required to maintain the flow;	**(11.45 kW)**
(v)	The velocity gradient at the pipe wall;	**(300 /s)**
(vi)	The velocity and shear stress at 8 mm from the wall.	**(198 kN/m^3)**

[EASY]

Ques. 2 Two parallel plates kept 100 mm apart have laminar flow of oil between them with a maximum velocity of 1.5 m/s. Calculate:

(i)	The discharge per meter width;	**(0.1 m^3/s per m)**
(ii)	The shear stress at the plates;	**(147 N/m^2)**
(iii)	The difference in pressure between two points 20 m apart;	**(58.8 kN/m^2)**
(iv)	The velocity gradient at the plates;	**(60 /sec)**
(v)	The velocity at 20 mm from the plate	**(0.96 m/s)**

Assume viscosity of oil to be 24.5 poise.

[MODERATE]

Ques. 3 A liquid of viscosity of 0.9 poise is filled between two horizontal plates 10 mm apart. If the upper plate is moving at 1 m/s with respect to the lower plate which is stationary and the pressure difference between two sections 60 m apart is 60 kN/m^2, determine:

(i)	The velocity distribution,	**(u = y (155.55 – 5555.5y))**
(ii)	The discharge per unit width, and	**(0.005925 m^3/s)**
(iii)	The shear stress on upper plate.	**(4 N/m^2)**

[MODERATE]

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Ques. 4 A smooth pipe of diameter 80 mm and 800 m long carries water at the rate of 0.480 m^3/min. Calculate the loss of head, wall shearing stress, centre line velocity, velocity and shear stress at 30 mm from pipe wall. Also calculate the thickness of laminar sub-layer. Take kinematic viscosity of water as 0.015 stokes. Take the value of co-efficient of friction 'f' from the relation given as

$$f = 0.0791/(Re)^{1/4}.$$

(23.42 m, 5.866N/m^2, 1.88 m/s, 1.4665 N/m^2, 1.825 m/s, 0.02274 cm)

[DIFFICULT]

Ques. 5 For turbulent flow in a pipe of diameter 300 mm, find the discharges when the centreline velocity is 2 m/s and the velocity at a point 100 mm from the centre as measured by pitot tube is 1.6 m/s.. **(0.1027 m^3/s)**

[DIFFICULT]

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Fluid Mechanics and Machines

Tutorial Sheet 7– Flow through Pipes

Ques. 1 Find the head lost due to friction in a pipe of diameter 300 mm and length 50 m, through which water is flowing at a velocity of 3 m/s using (i) Darcy formula, (ii) Chezy's formula for which C=60. Take kinematic viscosity for water = 0.01 stoke.

(0.7828 m, 1.665 m) [EASY]

Ques. 2 Water is flowing through a pipe of diameter 200 mm with a velocity of 3 m/s. Find the head lost due to friction for a length of 5 m if the co-efficient of friction is given by $f = 0.002 + 0.09/Re^{0.3}$, where Re is Reynolds Number. The kinematic viscosity of water = 0.01 stoke. **(0.993 m 0f water) [MODERATE]**

Ques. 3 A horizontal pipe of diameter 500 mm is suddenly contracted to a diameter of 250 mm. The pressure intensities in the large and smaller pipe are given as 13.734 N/cm^2 and 11.772 N/cm^2 respectively. Find the loss of head due to contraction if Cc = 0.62. Also determine the rate of flow of water. **(0.571 m, 268.3 lit/s) [MODERATE]**

Ques. 4 A horizontal pipe line 40 m long is connected to a tank at one end and discharges freely into the atmosphere at the other end. For the first 25 m of its length from the tank, the pipe is 150 mm diameter and its diameter is suddenly enlarged to 300mm. The height of water level in the tank is 8 m above the centre of the pipe. Considering all losses of head which occur, determine the rate of flow. Take f = 0.01 for both sections of the pipe.

(78.67 lit/s) [DIFFICULT]

Ques. 5 For the last problem. Draw hydraulic gradient and total energy line. **[DIFFICULT]**

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Fluid Mechanics and Machines

Tutorial Sheet 8 – Orifices and Mouthpieces

Ques. 1 The head of water over an orifice of diameter 100mm is 10 m. The water coming out from orifice is collected in a circular tank of diameter 1.5 m. The rise of water level in this tank is 1 m in 25 seconds. Also the co-ordinates of a point on the jet, measured from vena-contracta are 4.3 m horizontal and 0.5 m vertical. Find the co-efficient C_d, C_v, and Cc.

(0.643, 0.96, 0.669) [EASY]

Ques. 2 A pipe, 100 mm in diameter has a nozzle attached to it at the discharge end, the diameter of the nozzle is 50 mm. The rate of discharge of water through the nozzle is 20 litres/sec and the pressure at the base of the nozzle is 5.886 N/cm^2. Calculate the co-efficient of discharge. Assume that the base of the nozzle and outlet of the nozzle are at the sane elevation.

(0.909) [EASY]

Ques. 3 A rectangular orifice of 2 m width and 1.2 m deep is fitted in one side of a large tank. The water level on one side of the orifice id 3 m above the top edge of the orifice, while on the other side of the orifice, the water level id 0.5 m below its top edge. Calculate the discharge through the orifice if $C_d = 0.64$. **(12.5329 m^3/s.) [MODERATE]**

Ques. 4 A circular tank of diameter 4 m contains water upto a height of 5 m. The tank os provided with an orifice of diameter 0.5 m at the bottom. Find the time taken by water

(i) to fall from 5m to 2m **(39.58 sec)**

(ii) for completely emptying to tank. Take $C_d = 0.6$. **(107.7 sec)**

[DIFFICULT]

Ques. 5 Find the discharge from a 100 mm diameter external mouthpiece, fitted to a side of a large vessel if the head over the mouthpiece is 4 m. **(0.05948 m^3/s) [MODERATE]**

Ques. 6 An external cylinder mouthpiece of diameter 150 mm is discharging water under a constant head of 6 m. Determine the discharge and absolute pressure head of water at vena-contracta. Take $C_d = 0.855$ and C_c =for vena-contracta = 0.62. Atmospheric pressure head = 10.3 m of water. **(0.1639 m^3/s, 4.96 m) [DIFFICULT]**

Ques. 7 An internal mouthpiece of 80 mm diameter is discharging water under a constant head of 8 meters. Find the discharges through mouthpiece, when

(i) The mouthpiece is running free, and **(22.26 lit/s)**

(ii) The mouthpiece is running full. **(31.47 lit/s) [MODERATE]**

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Fluid Mechanics and Machines
Tutorial Sheet 9– Notches and Weirs

Ques. 1 Determine the height of a rectangular weir of length 6 m to be built across a rectangular channel. The maximum depth of water on the upstream side of the weir is 1.8 m and discharge is 2000 lit/s. Take $C_d = 0.6$ and neglect end contraction.**(1.472 m) [EASY]**

Ques. 2 Water flows through a triangular right-angled weir first and then over a rectangular weir of 1 m width. The discharge co-efficient of the triangular and rectangular weirs are 0.6 and 0.7 respectively. If the depth of water over the triangular weir is 360 mm, find the depth of water over the rectangular weir. **(141.5 mm) [EASY]**

Ques. 3 Find the discharge through a trapezoidal notch which is 1m wide at the top and 0.40 m at the bottom and is 30 cm in height. The head of water on the notch is 20 cm. Assume C_d for rectangular portion as 0.62 while for triangular portion 0.60.**(90.84 litre/s.) [EASY]**

Ques. 4 Find the time required to lower the water level from 3 m to 2 m in a reservoir of dimension 80 m multiplied by 80 m, by a rectangular notch of length1.5 m. Take C_d = 0.62. **(10 min 5 sec) [MODERATE]**

Ques. 5 (a) A broad crested weir of 50 m length, has 50 cm height of water above its crest. Find the maximum discharge. Take $C_d = 0.60$. Neglect velocity of approach.
(18.084 m^3/s) [MODERATE]

(b) If the velocity of approach is to be taken into consideration, find the maximum discharge when the channel has a cross-sectional area of 50 m^2 on the upstream side.
(18.412 m^3/s) [MODERATE]

Ques. 6 An Ogee weir 5 meter long has a head of 40 cm of water. If $C_d = 0.6$, find discharge over the weir. **(2.2409 m^3/s) [DIFFICULT]**

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Fluid Mechanics and Machines

Tutorial Sheet 10 – Dimensional Analysis

Ques. 1 Determine the dimensions of the quantities given below: (i) angular velocity, (ii) angular acceleration, (iii) discharge, (iv) kinematic viscosity, (v) Force, (vi) specific weight, and (vii) dynamic viscosity. **[EASY]**

Ques. 2 The efficiency of a fan depends on density, dynamic viscosity of the fluid, angular velocity, diameter of the rotor and the discharge. Express efficiency in terms of dimensionless numbers. **[MODERATE]**

Ques. 3 Using Buckingham's π-theorem, show that the velocity through a circular orifice is given by

$$V = \sqrt{2gh}\,\Phi\left[\frac{D}{H}, \frac{\mu}{\rho V H}\right]$$

Where H is the head causing flow, D is the diameter of the orifice, μ is the co-efficient of viscosity, ρ is the mass density and g is the acceleration due to gravity.**[MODERATE]**

Ques. 4 Derive on the basis of dimensional analysis suitable parameters to present the thrust developed by a propeller. Assume that the thrust P depends upon the angular velocity ω, speed of advance V, diameter D, dynamic viscosity μ, mass density ρ, elasticity of the fluid medium which can be denoted by the speed of sound in the medium C.

.**[DIFFICULT]**

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Mechanical Engineering Department, SKIT, Jaipur

Fluid Mechanics and Machines

Tutorial Sheet 11 – Impact of Jet

Ques. 1 Water is flowing through a pipe at the end of which a nozzle is fitted. The diameter of the nozzle is 100 mm and the head of water at the centre nozzle is 100 m. Find the force exerted by the jet of water on a fixed vertical plate. The co-efficient if velocity is given as 0.95. . **[EASY]**

Ques. 2 A jet of water of diameter 75 mm moving with a velocity of 25 m/s strikes a fixed plate in such a way that the angle between the jet and plate is 60°. Find the force exerted by the jet on the plate (i) in the direction normal to the plate and (ii) in the direction of the jet.

.**[MODERATE]**

Ques. 3 A jet of water of diameter 50 mm moving with a velocity of 40 m/s, strikes a curved fixed symmetrical plate at the centre. Find the force exerted by the jet of water in the direction of the jet, if the jet is deflected through an angle of 120° at the outlet of the curved plate.

[MODERATE]

Ques. 4 A jet of water of diameter 75 mm moving with a velocity of 30 m/s, strikes a curved fixed plate tangentially at one end at an angle of 30° to the horizontal. The jet leaves the plate at an angle of 20° to the horizontal. Find the force exerted by the jet on the plate in the horizontal and vertical direction. **[MODERATE]**

Ques. 5 A nozzle of 50 mm diameter delivers a stream of water at 20 m/s perpendicular to a plate that moves away from the jet at 5 m/s. Find: (i) the force on the plate, (ii) the work done, and (iii) the efficiency of the jet. **[DIFFICULT]**

Ques. 6 A 7.5 cm diameter jet having a velocity of 30 m/s strikes a flat plate, the normal of which is inclined at 45° to the axis of the jet. Find the normal pressure on the plate: (i) when the plate is stationary, and (ii) when the plate is moving with a velocity of 15 m/s and away from the jet. Also determine the power and efficiency of the jet when the plate is moving.

[MODERATE]

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Ques. 7 A jet of water of diameter 7.5 cm strikes a curved plate at its centre with a velocity of 20 m/s. The curved plate is moving with a velocity of 8 m/s in the direction of the jet. The jet is deflected through an angle of 165°. Assuming the plate is smooth find: (i) Force exerted on the plate in the direction of jet, (ii) Power of the jet, and (iii) Efficiency of the jet. **[DIFFICULT]**

Ques. 8 A jet of water having a velocity of 20 m/s strikes a curved vane, which is moving with a velocity of 10 m/s. The jet makes an angle of 20° with the direction of motion of the vane at inlet and leaves at an angle of 130° to the direction of motion of vane an outlet. Calculate: (i) Vane angles, so that the water enters and leaves the vane without shock and (ii) Work done per second per unit weight of water striking the vane per second.

[DIFFICULT]

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Fluid Mechanics and Machines

Tutorial Sheet 12 – Hydraulic Turbines

Ques. 1 A Pelton wheel turbine has a mean bucket speed of 10 m/s with a jet of water flowing at the rate of 700 litres/s under a head of 30 meters. The buckets deflect the jet through an angle of 160°. Calculate the power given by water to the runner and hydraulic efficiency of the turbine. Assume co-efficient of velocity as 0.98. **[EASY]**

Ques. 2 A Pelton wheel is to be designed for a head of 60 m when running at 200 rpm. The Pelton wheel develops 95.6475 kW shaft power. The velocity of the buckets = 0.45 times the velocity of the jet, overall efficiency = 0.85 co-efficient of the velocity is equal to 0.98. **[EASY]**

Ques. 3 An inward flow reaction turbine has external and internal diameters as 1 m and The hydraulic efficiency of the turbine is 90% when the head on the turbine is 36 m. The velocity of flow at outlet is 2.5 m/s t outlet is and discharge at outlet is radial. If the vane angle at the outlet is 15° and width of the wheel is 100 mm at inlet and outlet, determine: (i) the guide blade angle, (ii) speed of the turbine, (iii) vane angle of the runner at inlet, (iv) volume flow rate of turbine and (v) power developed. **[MODERATE]**

Ques. 4 An outward flow reaction turbine has internal and external diameters of the runner as 0.6 m and 1.2 m respectively. The guide blade angle is 15° and velocity of flow through the runner is constant and equal to 4 m/s. If the speed of the turbine is 200 rpm, head on the turbine is 10 m and discharge at outlet is radial, determine: (i) the runner vane angles at inlet and outlet, (ii) work done by the water on the runner per second per unit weight of water striking per second, (iii) hydraulic efficiency, and (iv) the degree of reaction. **[MODERATE]**

Ques. 5 A Francis turbine with an overall efficiency of 75% is required to produce 148.25 kW power. It is working under a head of 7.62 m. The peripheral velocity = 0.26 $\sqrt{2gh}$ and the radial velocity of flow at inlet = 0.96 $\sqrt{2gh}$. The wheel runs at 150 rpm and the hydraulic losses in the turbine are 22% of the available energy. Assuming radial discharge, determine: (i) the guide blade angle, (ii) the wheel vane angle at inlet, (iii) diameter of the wheel at inlet, and (iv) width of the wheel at inlet. **[DIFFICULT]**

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Ques. 6 A Kaplan turbine working under a head of 20 m develops 11772 kW shaft power. The outer diameter of the runner is 3.5 m and hub diameter is 1.75 m. The guide blade angle at the extreme edge of the runner is 35°. The hydraulic and overall efficiencies are 88% and 84% respectively. If the velocity of whirl is zero at outlet, determine: (i) runner vane angles at inlet and outlet at the extreme edge of the runner, and (ii) speed of the turbine.

[DIFFICULT]

Ques. 7 A conical draft-tube having diameter at the top as 2 m and pressure head at 7 m of water (vacuum), discharges water at outlet with a velocity of 1.2 m/s at the rate of 25 m^3/s. If atmospheric pressure head is 10.3 m of water and losses between the inlet and outlet of draft-tubes are negligible, find the length of draft-tube immersed in water. Total length of tube is 5 m.

[MODERATE]

Ques. 8 A turbine is to operate under a head of 25 m at 200 rpm. The discharge is 9 m^3/s. If the efficiency is 90%, determine the performance of the turbine under a head of 20 meters.

[MODERATE]

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Tutorial No. 1

B.Tech./ Semester – VB **Branch: Mechanical Engineering**
Subject: Manufacturing Technology **Subject Code: 5ME4-03**

Q1 An orthogonal operation is carried out at 20m/min, cutting speed, using a cutting tool of rake angle 15deg.The chip thickness is 0.4mm and uncut chip thickness is 0.2mm. [E]

Q2 In an orthogonal cutting operation, the cutting velocity is 30m/min and the chip velocity 15m/min. If the rake angle of the tool is 10^0 , determine the shear velocity? [M]

Q3 A 100 mm bar is turned by means of a tool with a rake angle of 15° orthogonally. Depth of cut is 5 mm while the feed rate is 0.25 mm/rev. If the mean length of a cut chip representing one rotation of the work piece is 90.5 mm, find the shear plane angle. [M]

Q4 In an orthogonal cutting of a steel component with carbide tool, the following data was obtained:
Tool rake angle = 10° Chip width = 6 mm
Uncut chip thickness = 0.10 mm
Chip thickness ratio = 0.33
Horizontal cutting force = 1650 N
Vertical cutting force = 1290 N
Sketch the force diagram and calculate the mean shear stress on the shear plane. [D]

Q5 Derive the expression for shear angle in orthogonal cutting in terms of rake angle and chip thickness ratio. [M]

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Tutorial No. 2

B.Tech./ Semester – VB **Branch: Mechanical Engineering**
Subject: Manufacturing Technology **Subject Code: 5ME4-03**

Q1 In a shaping process, the number of double strokes per minute is 30 and the quick return ratio is 0.6. If the length of the stroke is 250mm, determine the average cutting velocity in m/min. [E]

Q2 In a single pass drilling operation, a through hole of 15 mm diameter is to be drilled in a steel plate of 50mm thickness. Drill spindle speed is 500rpm, feed is 0.2mm/rev0.2mm/rev and drill point angle is 118^0. Assuming 2mm clearance at approach and exit, compute the total drill time (in seconds). [M]

Q3 A milling cutter having 88 teeth is rotating at 100 rpm. The work piece feed is set at 40mm/min. Determine the feed per tooth. [E]

Q4 If the cutting speed is doubled, what will be the effect on tool life. In Taylor's tool life equation, n =0.2. [E]

Q5 Free cutting steel work pieces of 200 mm long and 100 mm in diameter are to be turned on a lathe using a feed of 0.15 mm/rev and a depth of cut of 2 mm. It is possible to use brazed and throw away type cemented carbide tools for the operation. The overhead cost is `80 per hour, while the tool life constants are n = 0.25 and C = 200. Compare the minimum cost and maximum productivity times and costs of these with the following data:

Brazed tools	Throw away tools
Tool cost = Rs. 90	Rs.30
No of regrinds = 10	No. of edges = 4
Regrinding cost = Rs.15	
Tool change time = 3 min	1 min

[D]

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Tutorial No. 3

B.Tech./ Semester – VB **Branch: Mechanical Engineering**
Subject: Manufacturing Technology **Subject Code: 5ME4-03**

Q1 In a grinding wheel marked with A − 48 − L − 7 − V − 25, what does L refers to? [E]

Q2 What is high energy rate forming? List down the high energy rate forming processes. [E]

Q3 In a horizontal axis surface grinder a flat surface of size 300 mm X 100mm is to be ground. The grinding wheel used is 300 mm in diameter with a thickness of 15 mm. Calculate the grinding time. Assume a table speed of 7.5 m/min, wheel speed of 10 m/s and infeed rate = 2.5mm/pass.? [M]

Q4 In a vertical axis surface grinder a flat surface of size 300 X 100 mm is to be ground. The grinding wheel used is 300 mm in diameter with a thickness of 10 mm. Calculate the grinding time. Assume a table speed of 5 m/min. [M]

Q5 A flat surface of 250 mm long and 150 mm wide is to be produced on a horizontal axis milling machine. A HSS slab mill of 100 mm diameter and 150 mm width is to be used for the purpose. The milling cutter has 8 teeth. Calculate the machining time assuming that entire stock can be removed in one depth of 2 mm and MRR. Consider cutting speed = 20m/min, feed=0.13 /tooth. [D]

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Tutorial Sheets

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Tutorial No. 1

Question 1: Firm uses simple exponential smoothing with $\alpha = 0.2$ to forecast demand. The forecast for the first week of January 400 units, whereas actual demand turned out to be 450 units.

(i) Forecast the demand for the second week of January.

(ii) Assume that the actual demand during the second week of January turned out to be 460 units, forecast the demand up to February third week, assuming the subsequence demands as 465, 434, 420, 498, and 462 units.

Question 2: The quarterly demand for the past three years for a particular product is given in following table:

2019		2020		2021	
Quarter	**Demand**	**Quarter**	**Demand**	**Quarter**	**Demand**
1	2100	1	2700	1	3500
2	1700	2	2400	2	3000
3	2700	3	3500	3	4300
4	3200	4	3500	4	4800

There are both trend and seasonal factors. The cycle is of one year. Use time series decomposing to forecast demand for the quarterly sales of the next year.

Question 3: Use the sales data given below to determine: (a) the least squares trend line, and (b) the predicted value for 2022 sales.

Year	Sales (Units)
2015	100
2016	110
2017	122
2018	130
2019	139
2020	152
2021	164

Question 4: Auto sales at Chevrolet showroom are shown below. (a) Develop a 3-week moving average. (b) Prepare the forecast for auto sales assigning the weights as 3, 2 and 1 to three most recent weeks.

Week	1	2	3	4	5	6
Sales	8	10	9	11	10	13

Question 5: Given the forecast demand and actual demand for 10-foot fishing boats, compute the tracking signal and MAD.

Year	Forecast Demand	Actual Demand
1	78	71
2	75	80
3	83	101
4	84	84
5	88	60
6	85	73

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Question 6: Exponential smoothing is used to forecast automobile battery sales. Two value of α are examined, α=0.8 and α =0.5. Evaluate the accuracy of each smoothing constant. Which is preferable? (Assume the forecast for January was 22 batteries.) Actual sales are given below:

Month	**Actual Battery Sales**
January	20
February	21
March	15
April	14
May	13
June	16

Question 7: Over the past year Meredith and Smunt Manufacturing had annual sales of 10,000 portable water pumps. The average quarterly sales for the past 5 years have averaged: spring 4,000, summer 3,000, fall 2,000 and winter 1,000. Compute the quarterly index.

Question 8: Obtain estimates of quarter relatives for these data using the centered moving average method.

Quarter	**Year 1**	**Year 2**	**Year 3**	**Year 4**
	Demand	**Demand**	**Demand**	**Demand**
1	14	28	45	58
2	18	36	54	
3	35	60	84	
4	46	71	88	

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Solutions to Tutorial 1

Solution 1(a):

$F_t=F_{t-1}+\alpha(A_{t-1}- F_{t-1})$

$= 400+0.2(450-400)= 410$

Solution 1(b):

Month	**Week**	**Actual Demand A_{t-1}**	**Forecast F_{t-1}**	**Exponential Forecast (α=0.2) or New Forecast $F_t=F_{t-1}+\alpha(A_{t-1}- F_{t-1})$**
January	1	450	400	410
	2	460	410	420
	3	465	420	429
	4	434	429	430
February	1	420	430	428
	2	498	428	442
	3	462	442	446

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Year 2019		Year 2020		Year 2021		Individual Quarter value/Avg Quarter	Individual Quarter value/Avg Quarter	Individual Quarter value/Avg Quarter
Quarter	**Demand**	**Quarter**	**Demand**	**Quarter**	**Demand**	**(Year 2019)**	**(Year 2020)**	**(Year 2021)**
1	2100	1	2700	1	3500	=2100/2425 =0.87	=2700/3025 =0.89	=3500/3900 =0.90
2	1700	2	2400	2	3000	=1700/242 =0.70	=2400/3025 =0.79	=3000/3500 =0.77
3	2700	3	3500	3	4300	=2700/2425 =1.11	=3500/3025 =1.16	=4300/3900 =1.10
4	3200	4	3500	4	4800	=3200/2425 =1.32	=3500/3025 =1.16	=4800/3900 =1.23
Total	**9700**		**12100**		**15600**			
AVG	2425		**3025**		**3900**			

Solution 2:

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	Individual Quarter value/Avg Quarter (Year 2019)	Individual Quarter value/Avg Quarter (Year 2020)	Individual Quarter value/Avg Quarter (Year 2021)	Average	S.I or Quarter Relative
Q1	0.87	0.89	0.90	=(0.87+0.89+0.90)/3 =0.89	**=0.89/1 =0.89**
Q2	0.70	0.79	0.77	=(0.70+0.79+0.77) =0.75	**=0.75/1 =0.75**
Q3	1.11	1.16	1.10	=(1.11+1.16+1.10) =1.12	**=1.12/1 =1.12**
Q4	1.32	1.16	1.23	=(1.32+1.16+1.23) =1.24	**=1.24/1 =1.24**
			AVERAGE	**=(0.89+0.75+1.12+1.24)/4 =1**	

Year	t	Demand (y)	t^2	ty
2019	1	9700	1	9200
2020	2	12100	4	24200
2021	3	15600	9	46800
Sum	6	36900	14	80700

$$\bar{t} = \frac{\sum t}{n} = \frac{6}{3} = 2$$

$$b = \frac{n\sum ty - \sum t \sum y}{n(\sum t^2 - (\sum t)^2)} = \frac{3(80700) - (6)(37400)}{3(14) - (6)^2} = 2950$$

$a = \bar{y} - b\bar{t} = 12466.67 - (2950)(2) = 6566.67$

Therefore, the least squares trend equation is:

$y = 6566.67 + 2950t$

Expected demand for 2022= $a + bt = 6566.67 + 2950(4) = 18366.67$

Expected demand in each quarter=$\frac{18366.67}{4}$ = 4591.67

Quarter	**Seasonality Index or Quarter Relative**	**Expected Demand in Quarter(s) in year 2016 = Seasonality Index x Expected quarterly demand for 2016, i.e., 18700**
1	0.89	=(0.89)(4591.67) =**4065.12**
2	0.75	=(0.75)(4591.67) =**3464.64**
3	1.12	=(1.12)(4591.67) =**5162.55**
4	1.24	=(1.24)(4591.67) =**5674.35**

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Solution 3 (a):

Year	Time Period (X)	Sales (Units) (Y)	X^2	XY
2015	1	100	1	100
2016	2	110	4	220
2017	3	122	9	366
2018	4	130	16	520
2019	5	139	25	695
2010	6	152	36	912
2021	7	164	49	1148
	Sum X = 28	Sum Y =917	Sum X^2=140	Sum XY = 3961

$$\bar{x} = \frac{\sum x}{n} = \frac{28}{7} = 4$$

$$\bar{y} = \frac{\sum y}{n} = \frac{917}{7} = 131$$

$$b = \frac{\sum xy - n\bar{x}\bar{y}}{\sum x^2 - n\bar{x}^2} = \frac{3961 - (7)(4)(131)}{140 - (7)(4^2)} = \frac{293}{28} = 10.46$$

$$a = \bar{y} - b\bar{x} = 131 - (10.46 \times 4) = 89.16$$

Therefore, the least squares trend equation y=

$$= a + bx = 89.16 + 10.46\,x$$

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Solution 3(b): To project demand in 2008, we denote the year 2008 as $x = 8$, and:

Sales in 2008 = 89.16 + 10.46 * 8 = 172.84

Solution 4 (a):

$$\text{Moving average} = \frac{\sum \text{demand in previous n periods}}{\text{n}}$$

Week	Auto Sales	Three-Week Moving Average
1	8	
2	10	
3	9	
4	11	(8 + 9 + 10) / 3 = 9
5	10	(10 + 9 + 11) / 3 = 10
6	13	(9 + 11 + 10) / 3 = 10
7	-	(11 + 10 + 13) / 3 = 11 1/3

Solution 4 (b):

$$\text{Weighted moving average} = \frac{\sum (\text{weight for period n})(\text{demand in period n})}{\sum \text{weights}}$$

Week	Auto Sales	Three-Week Moving Average
1	8	
2	10	
3	9	
4	11	[(3*9) + (2*10) + (1*8)] / 6 = 9 1/6

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5	10	[(3*11) + (2*9) + (1*10)] / 6 = 10 1/6
6	13	[(3*10) + (2*11) + (1*9)] / 6 = 10 1/6
7	-	[(3*13) + (2*10) + (1*11)] / 6 = 11 2/3

Solution 5:

Year	Forecast Demand	Actual Demand	Error	RSFE (Running Sum of Forecast Errors)
1	78	71	-7	-7
2	75	80	5	-2
3	83	101	18	16
4	84	84	0	16
5	88	60	-28	-12
6	85	73	-12	-24

$$\text{MAD} = \frac{\sum|\text{Forecast errors}|}{n} = \frac{70}{6} = 11.7$$

Year	Forecast Demand	Actual Demand	|Forecast Error|	Cumulative Error	MAD	Tracking Signal
1	78	71	7	7	7.0	-1.0
2	75	80	5	12	6.0	-0.3
3	83	101	18	30	10.0	+1.6

4	84	84	0	30	7.5	+2.1
5	88	60	28	58	11.6	-1.0
6	85	73	12	70	11.7	-2.1

$$\text{Tracking Signal} = \frac{\text{RFSE}}{\text{MAD}} = \frac{-24}{11.7} = 2.1 \text{ MADs}$$

Solution 6:

Month	**Actual Battery Sales**	**Rounded Forecast with α =0.8**	**Absolute Deviation with α =0.8**	**Rounded Forecast with α =0.5**	**Absolute Deviation with α =0.5**
January	20	22	2	22	2
February	21	20	1	21	0
March	15	21	6	21	6
April	14	16	2	18	4
May	13	14	1	16	3
June	16	13	3	15	1
		Sum =	15		16
$MAD = \frac{\sum \text{deviations}}{n}$			2.5		2.75
SE			3.7		4.1

On the basis of this analysis, a smoothing constant of **α** = 0.8 is preferred to that of **α** = 0.5 because it has a smaller MAD.

Solution 7:

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Sales of 10,000 units annually divided equally over the 4 seasons is $10{,}000/4 = 2{,}500$ and the seasonal index for each quarter is: spring $4{,}000/2{,}500 = 1.6$; summer $3{,}000/2{,}500 = 1.2$; fall $2{,}000/2{,}500 = .8$; winter $1{,}000/2{,}500 = .4$.

Solution 8:

Year	Quarter	Demand	MA_4	MA_2	Demand/MA_2
1	1	14			
	2	18	28.25		
	3	35	31.75	30.00	1.17
	4	46	36.25	34.00	1.35
2	1	28	42.50	39.38	0.71
	2	36	48.75	45.63	0.79
	3	60	53.00	50.88	1.18
	4	71	57.50	55.25	1.29
3	1	45	63.50	60.50	0.74
	2	54	67.75	65.63	0.82
	3	84	71.00	69.38	1.21
	4	88			
4	1	58			

	QUARTER			
	1	2	3	4
	0.71	0.79	1.17	1.35
	0.74	0.82	1.18	1.29
	1.45	1.61	1.21	2.64
			3.56	
Average for the quarter:	0.725	0.805	1.187	1.320

The sum of these relatives is 4.037. Multiplying each by 4.00/4.037 will standardize the relatives, making their total equal 4.00. The resulting relatives are quarter 1, .718; quarter 2, .798; quarter 3, 1.176; quarter 4, 1.308.

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Tutorial No. 2

Question 1: A company that handles hazardous waste wants to minimize the shipping cost for shipments to a disposal center from five receiving stations it operates. Given the locations of the receiving stations and the volumes to be shipped daily, determine the location of the disposal center.

Location of processing Station (x, y)	Volume, Tons per Day
10,5	26
4,1	9
4,7	25
2,6	30
8,7	40

Question 2: A photo-processing company intends to open a new branch store. The following table contains information on two potential locations. Which is the better alternative?

Table 1

		Score (Out of 100)	
Factor	**Weight**	**Alt.1**	**Alt.2**
Proximity to existing store	0.10	100	60
Traffic Volume	0.05	80	80
Rental costs	0.40	70	90
Size	0.10	86	92
Layout	0.20	40	70
Operating Cost	0.15	80	90

Question 3: Using the information contained in the Table 2 as shown below, do each of the following:

1. Draw a precedence diagram.
2. Assuming an eight-hour workday, compute the cycle time needed to obtain an output of 400 units per day.
3. Determine the minimum number of workstations required.
4. Assign tasks to workstations using this rule: Assign tasks according to greatest number of following tasks. In case of a tie, use the tiebreaker of assigning the task with the longest processing time first.
5. Compute the resulting percent idle time and efficiency of the system.

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Table 2

Task	Immediate Predecessor	Task Time (in minutes)
a	-----	0.2
b	a	0.2
c	-----	0.8
d	c	0.6
e	b	0.3
f	d, e	1.0
g	f	0.4
h	g	0.3
		= 3.8

Question 4: Determine the coordinates of the center of gravity for the problem depicted in Figure 1. Assume that the shipments from the center of gravity to each of the four destinations will be equal quantities.

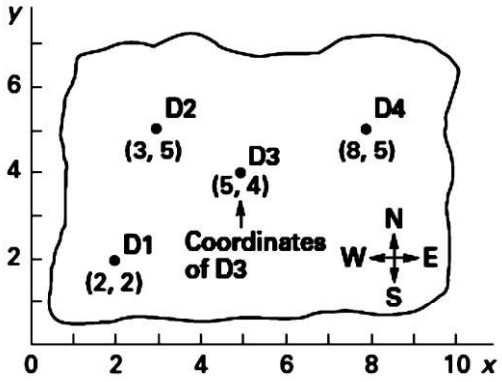

Figure 1

Question 5: A small producer of machine tools wants to move to a larger building, and has identified two alternatives. Location A has annual fixed costs of Rs. 800,000 and variable costs of Rs.14,000 per unit; location B has annual fixed costs of Rs.920,000 and variable costs of Rs.13,000 per unit. The finished items sell for Rs.17,000 each.

a. At what volume of output would the two locations have the same total cost?

b. For what range of output would location A be superior? For what range would B be superior?

Question 6: Develop a Muther-type grid using the letters A, O, and X for six departments so that these conditions are satisfied: 1 close to 2, 5 close to 2 and 6, 2 close to 5, and 3 not close to 1 or 2. Assume that any pair of combinations not mentioned have an O rating.

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Solutions to Tutorial - 2

Solution 1:

$$\bar{x} = \frac{\Sigma x_i Q_i}{\Sigma Q_i}$$

$$\bar{y} = \frac{\Sigma y_i Q_i}{\Sigma Q_i}$$

where

Q_i = Quantity to be shipped to destination i

x_i = x coordinate of destination i

y_i = y coordinate of destination i

x	y	Q	xQ	yQ
10	5	26	260	130
4	1	9	36	9
4	7	25	100	175
2	6	30	60	180
8	7	40	320	280
SUM		130	776	774
C.G.			**5.97**	**5.96**

(5.97, 5.95)

Solution 2:

		Scores (Out of 100)		Weighted Scores	
Factor	Weight	Alt. 1	Alt. 2	Alternative 1	Alternative 2
Proximity to existing store	.10	100	60	.10(100) = 10.0	.10(60) = 6.0
Traffic volume	.05	80	80	.05(80) = 4.0	.05(80) = 4.0
Rental costs	.40	70	90	.40(70) = 28.0	.40(90) = 36.0
Size	.10	86	92	.10(86) = 8.6	.10(92) = 9.2
Layout	.20	40	70	.20(40) = 8.0	.20(70) = 14.0
Operating costs	.15	80	90	.15(80) = 12.0	.15(90) = 13.5
				70.6	82.7

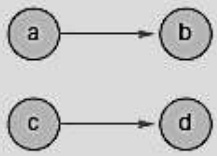
Alternative 2 is better because it has the higher composite score.

Solution 3:

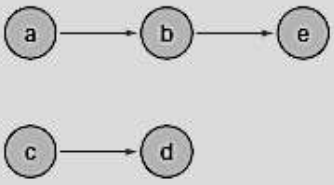
1. Drawing a precedence diagram is a relatively straightforward task. Begin with activities with no predecessors. We see from the list that tasks *a* and *c* do not have predecessors. We build from here.

Step 1:

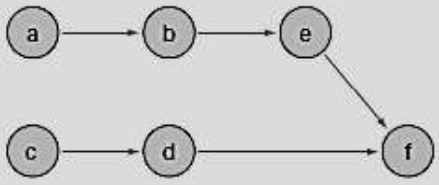
Step 2: Task *b* follows *a*, and *d* follows *c*.



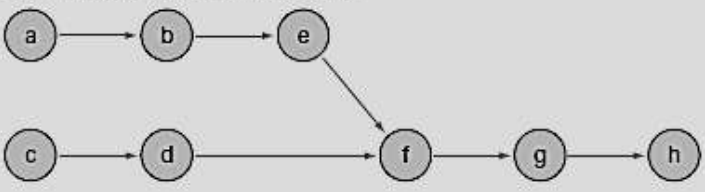
Step 3: Task *e* follows *b*.



Step 4: Task *f* follows *e*, and *d*.



Step 5: Task *g* follows *f*, and *h* follows *g*.



2. $$\text{Cycle time} = \frac{\text{Operating time}}{\text{Desired output rate}} = \frac{480 \text{ minutes per day}}{400 \text{ units per day}} = 1.2 \text{ minutes per cycle}$$

3. $$N_{\min} = \frac{\Sigma t}{\text{Cycle time}} = \frac{3.8 \text{ minutes per unit}}{1.2 \text{ minutes per cycle per station}} = 3.17 \text{ stations (round to 4)}$$

4. Beginning with station 1, make assignments following this procedure: Determine from the precedence diagram which tasks are eligible for assignment. Then determine which of the eligible tasks will fit the time remaining for the station. Use the tiebreaker if necessary. Once a task has been assigned, remove it from consideration. When a station cannot take any more assignments, go on to the next station. Continue until all tasks have been assigned.

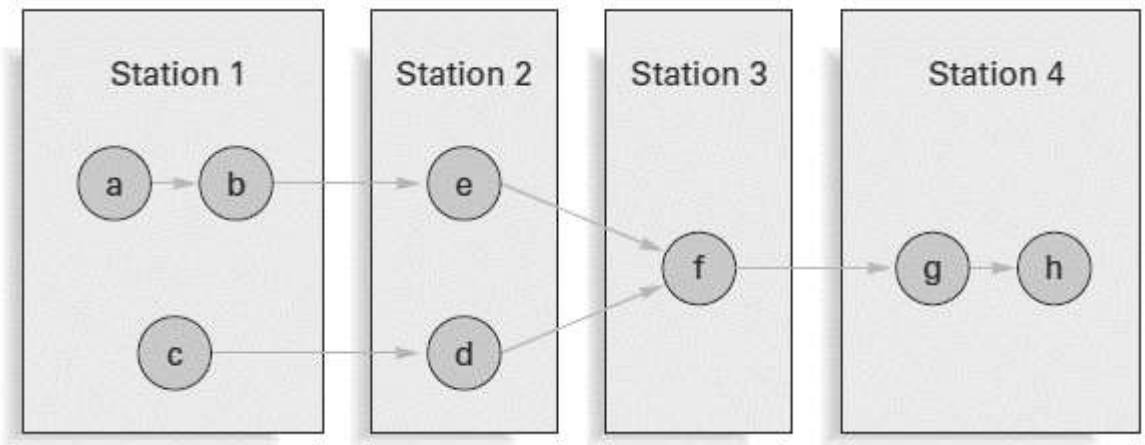
Station	Time Remaining	Eligible	Will Fit	Assign (task time)	Revised Time Remaining	Idle
1	1.2	a, c*	a, c*	a (0.2)	1.0	
	1.0	c, b**	c, b**	c (0.8)	0.2	
	0.2	b, d	b	b (0.2)	0.0	
	0	e, d	None	—		0.0
2	1.2	e, d	e, d	d (0.6)	0.6	
	0.6	e	e	e (0.3)	0.3	
	0.3***	f	None	—		0.3
3	1.2	f	f	f (1.0)	0.2	
	0.2	g	None	—		0.2
4	1.2	g	g	g (0.4)	0.8	
	0.8	h	h	h (0.3)	0.5	
	0.5	—	—	—		0.5
						1.0 min.

*Neither *a* nor *c* has any predecessors, so both are eligible. Task *a* was assigned since it has more followers.

**Once *a* is assigned, *b* and *c* are now eligible. Both will fit in the time remaining of 1.0 minute. The tie cannot be broken by the "most followers" rule, so the longer task is assigned.

***Although *f* is eligible, this task will not fit, so station 2 is left with 0.3 minute of idle time per 1.2-minute cycle.

These assignments are shown in the following diagram.



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5. Percent idle time $= \dfrac{1.0 \text{ min.}}{4 \times 1.2 \text{ min.}} \times 100 = 20.83\%.$

Efficiency $= 100\% - 20.83\% = 79.17\%$

Solution 4:

shipments from the center of gravity to each of the four destinations will be equal quantities.

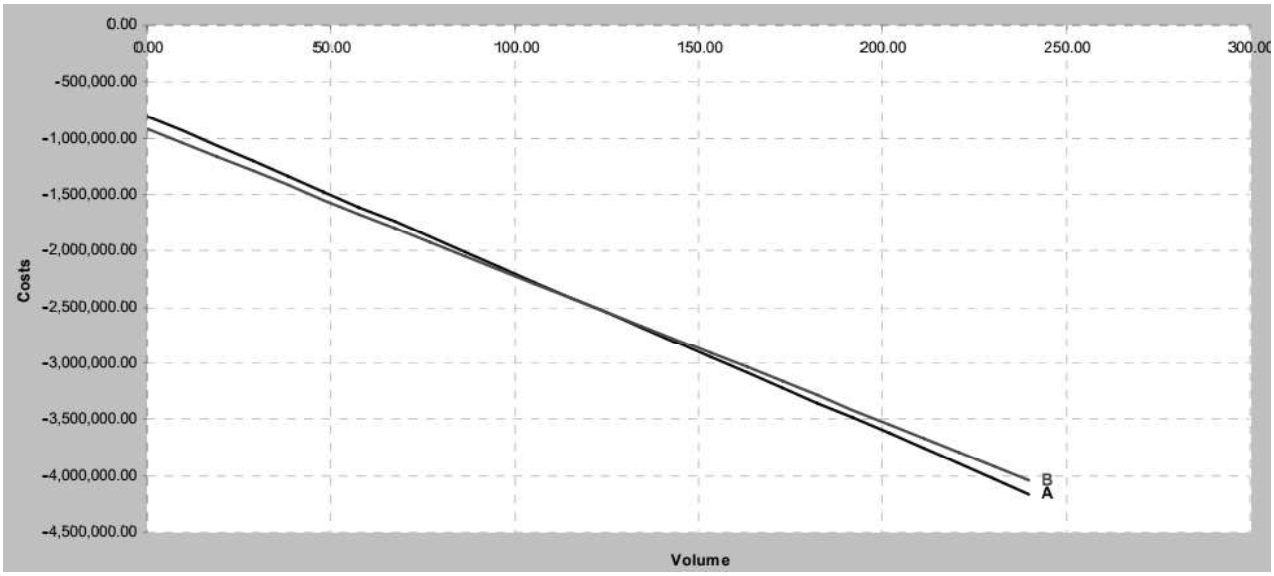
The coordinates of the destinations can be obtained from Figure

Destination	x	y
D1	2,	2
D2	3,	5
D3	5,	4
D4	8,	5
	18	16

$$\bar{x} = \frac{\Sigma x_i}{n} = \frac{18}{4} = 4.5 \qquad \bar{y} = \frac{\Sigma y_i}{n} = \frac{16}{4} = 4$$

Hence, the center of gravity is at (4.5,4), which places it just west of destination D3

Solution 5:



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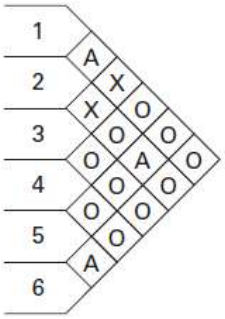
a. 120 units.

b. A: 0 to 119 (Location A has lowest cost when 0 <= Volume < 120 units)

B: 121+ (Location B has lowest cost when Volume > 120 units)

Solution 6:



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Tutorial No. 3

Question 1: A manager is attempting to put together an aggregate plan for the coming nine months. She has obtained a forecast of expected demand for the planning horizon. The plan must deal with highly seasonal demand; demand is relatively high in periods 3 and 4 and again in period 8, as can be seen from the following forecasts:

Period	1	2	3	4	5	6	7	8	9	Total
Forecast	190	230	260	280	210	170	160	260	180	1940

The department now has 20 full-time employees, each of whom produces 10 units of output per period at a cost of Rs.6 per unit. Beginning inventory for period 1 is zero. Inventory carrying cost is Rs.5 per unit per period, and backlog cost is Rs.10 per unit per period.
a. Will the current work force be able to handle the forecast demand?
b. Determine the total cost of the plan, including production, inventory, and backorder costs.

Question 2: Prepare a MPS schedule for the following situation: The forecast for each period is 70 units. The starting inventory is zero. The MPS rule is to schedule production if the projected inventory on hand is negative. The production lot size is 100 units. The following Table 1 shows committed orders.

Table 1

Period	Customer orders
1	80
2	50
3	30
4	10

Question 3: The following product structure tree indicates the components needed to assemble one unit of product W. Determine the quantities of each component needed to assemble 100 units of W.

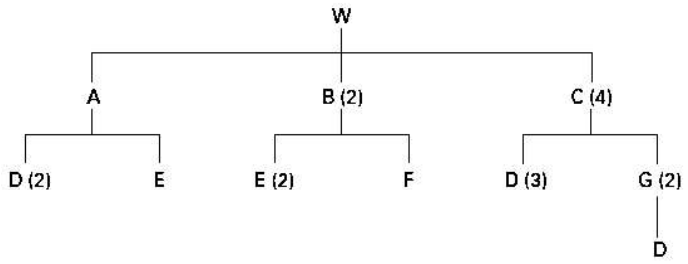

Figure 1

Question 4: The product structure tree for end item E follows (Figure 2). The manager wants to know the material requirements for ordered part R that will be needed to complete 120 units of E by the start of week 5. Lead times for items are one week for level 0 items, one week for level 1 items, and two weeks for level 2 items. There is a scheduled receipt of 60 units of M at the start of week 2 and 100 units of R at the start of week 1. Lot-for-lot ordering is used.

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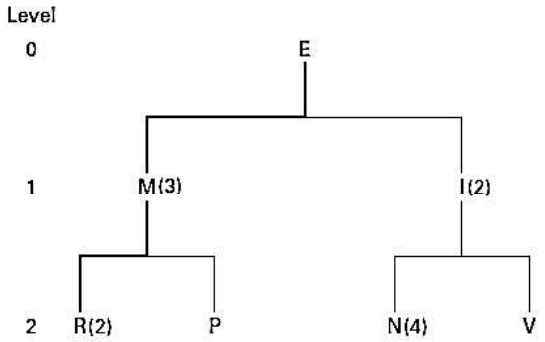

Figure 2

Question 5: Given the following production schedule in units and the production standards for labor and machine time for this product, determine the labor and machine capacity requirements for each week. Then compute the percent utilization of labor and machines in each week if labor capacity is 200 hours per week and machine capacity is 250 hours per week.

Table 2
Production Schedule

Week	1	2	3	4
Forecast	200	300	100	150

Labor 0.5 hour/unit
Machine 1.0 hour/unit

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Solutions to Tutorial No. 3

Solution 1:

a. With the current workforce of 20 people each producing 10 units per period, regular capacity is 1,800 units for the 9-month period. That is 140 units less than expected demand. So there will be a backlog of unfilled demand if actual demand equals the forecast.

b. The production plan is

Period	1	2	3	4	5	6	7	8	9	Total
Forecast	190	230	260	280	210	170	160	260	180	1,940
Output										
Regular	200	200	200	200	200	200	200	200	200	1,800
Overtime	—	—	—	—	—	—	—	—	—	—
Subcontract	—	—	—	—	—	—	—	—	—	—
Output – Forecast	10	(30)	(60)	(80)	(10)	30	40	(60)	20	(140)
Inventory										
Beginning	0	10	0	0	0	0	0	20	0	
Ending	10	0	0	0	0	0	20	0	0	
Average	5	5	10	0	0	0	10	10	0	10
Backlog	0	20	80	160	170	140	100	160	140	970
Costs										
Output										
Regular @ 6	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	10,800
Overtime										
Subcontract										
Inventory @ 5	25	25	0	0	0	0	0	0	0	50
Back order @ 10	0	200	800	1,600	1,700	1,400	1,000	1,600	1,400	9,700
Total	1,225	1,425	2,000	2,800	2,900	2,600	2,200	2,800	2,600	20,550

The total cost for this plan is Rs. 20,550.

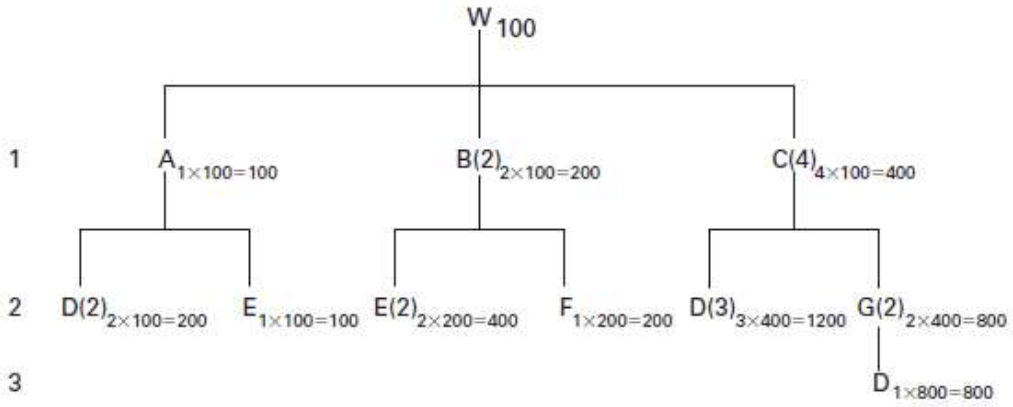
Solution 2:

Period	(A) Projected Inventory from Previous Period	(B) Requirements*	(C = A − B) Net Inventory before MPS	MPS	(MPS + C) Projected On-Hand Inventory
1	0	80	(80)	100	20
2	20	70	(50)	100	50
3	50	70	(20)	100	80
4	80	70	10	0	10

*Requirements equal the larger of forecast and customer orders in each period.

Starting Inv. = 0	1	2	3	4
Forecast	70	70	70	70
Customer orders	80	50	30	10
Projected on-hand inventory	20	50	80	10
MPS	100	100	100	0
ATP	20	50	60	0

Solution 3:



Summary:

Level	Item	Quantity
0	W	100
1	A	100
	B	200
	C	400
2	E	500
	F	200
	G	800
3	D	2,200

Solution 4:

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The master schedule for E and requirements plans for E, M, and R follow.

Master schedule for E

Week number	Beg. Inv.	1	2	3	4	5
Quantity						(120)

Item: E LT = 1 week						
Gross requirements						(120)
Scheduled receipts						
Projected on hand						
Net requirements						120
Planned-order receipts						(120)
Planned-order releases					(120)	

Multiplied by 3
(see product tree)

Item: M LT = 1 week						
Gross requirements					(360)	
Scheduled receipts			60			
Projected on hand			60	60	60	
Net requirements					300	
Planned-order receipts					(300)	
Planned-order releases				(300)		

Multiplied by 2
(see product tree)

Item: R LT = 2 weeks						
Gross requirements				(600)		
Scheduled receipts		100				
Projected on hand		100	100	100		
Net requirements				500		
Planned-order receipts				(500)		
Planned-order releases		(500)				

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Solution 5:

Convert the quantity requirements into labor and machine requirements by multiplying the quantity requirements by the respective standard times (i.e., multiply each quantity by .5 to obtain the labor hours and multiply each quantity by 1.0 to obtain the machine hours):

Week	1	2	3	4
Quantity	200	300	100	150
Labor hours	100	150	50	75
Machine hours	200	300	100	150

To compute utilization, divide the capacity requirements by the available capacity (200 hours per week for labor and 250 hours per week for machine) and multiply by 100. The results are

Week	1	2	3	4
Labor	50%	75%	25%	37.5%
Machine	80%	120%	40%	60%

Note that machine capacity in week 2 is overutilized (i.e., capacity is insufficient) because the utilization exceeds 100 percent. To compensate, some production could be shifted to weeks 1 and/or 3 where labor and machine time are available.

TUTORIAL SHEET #2

1. Derive an expression for amplitude and phase angle of vibrations because of a rotating unbalance.

[**RTU 2009, 2016**]

2. An air compressor weighing 450 kg operates at constant speed of 1750 r.p.m. Rotating parts are well balanced. The reciprocating part weighs 10 kg and crank radius is 100 mm. The mounting introduces a viscous damping of damping factor 0.15. Specify the spring for the mounting such that only 20% of the unbalanced force is transmitted to the foundation. Find out the amplitude of transmitted force.

3. Derive the expression for the response of a spring-mass-damper system subjected to harmonic excitation of base. Plot the response curves for different amounts of damping against the frequency ratio. **[RTU 2012]**

4. A vibrating system having mass 1 kg is suspended by a spring of stiffness 1000 N/m and it is put to harmonic excitation of 10 N. Assuming viscous damping, determine:
   (i) The resonant frequency
   (ii) The phase angle at resonance
   (iii) The amplitude at resonance
   (iv) The frequency corresponding to the peak amplitude. Take C = 40 N-s/m. [**RTU 2012, 2016**]

5. An electric motor is supported on a spring and a dashpot. The spring has the stiffness 6400 N/m and the dashpot offers resistance of 500 N at 4.0 m/s. The unbalanced mass of 0.5 kg rotates at 5 cm radius and the total mass of vibratory system is 20 kg. The motor runs at 400 rpm. Determine:
   (i) Damping factor
   (ii) Amplitude of vibration and phase angle
   (iii) Resonant speed and resonant amplitude and
   (iv) Forces exerted by the spring and dashpot on the motor. **[RTU 2016]**

6. A machine of 90 kg mass has a 15 kg rotor with 0.4 mm eccentricity. The mounting springs have a total stiffness of 80 kN/m and a damping factor of 0.02. The operating speed of machine is 600 r.p.m and the machine is constrained to move vertically. Find the dynamic amplitude of machine. **[RTU 2015]**

7. A single cylinder vertical petrol engine of total mass 300 kg is mounted upon a steel chassis and causes a vertical static deflection of 3 mm. The reciprocating parts of the engine have a mass of 21 kg and move through a vertical stroke of 130 mm with simple harmonic motion. A dashpot attached to the system offers a resistance of 480 N at a velocity of 0.3 m/sec. Determine:
   (i) The speed of the driving shaft at resonance and
   (ii) The amplitude of steady state vibration when the driving shaft of the engine rotates at 450 rpm. **[RTU 2012]**

8. A trailer has 900 kg mass when fully loaded and 300 kg when empty. The spring of the suspension has a stiffness of 300 kN/m. The damping ratio is 0.5 when the trailer is fully loaded. It travels on the road at 90 km/hr. The road has a sinusoidal profile with a wavelength of 5 m. Find the amplitude ratio of the trailer when it is fully loaded. **[RTU 2015]**

9. A vertical single stage air compressor of 600 kg mass operates at a constant speed of 200 r.p.m. and is mounted on springs having stiffness of 200 kN/m. Damping ratio is 0.2. Rotating parts are well balanced. The reciprocating parts weigh 20 kg. The stroke is 0.2 m. Find the dynamic amplitude of vertical motion and the phase difference between the motion and excitation force. **[RTU 2014]**

10. A torsional system consists of a disc of mass moment of inertia 10 kg-m^2, a torsional damper of damping constant 300 N-m-s/rad, and a steel shaft of diameter 4 cm and length 1 m (fixed at one end and attached to the disc at the other end). Modulus of rigidity of the steel shaft is 75 GPa. A steady angular oscillation of amplitude 2^0 is observed when a harmonic torque of magnitude 1000 N-m is applied to the disc. Find the frequency of applied torque and the maximum torque transmitted to the support. **[RTU 2013]**

11. A spring-mass system with mass 10 kg and stiffness 5000 N/m is subjected to a harmonic force of amplitude 250 N and frequency 'ω'. If the maximum amplitude of the mass is observed to be 100 mm, find the value of 'ω'. **[RTU 2013]**

12. Derive the relation for force transmissibility and draw a neat plot of the force transmissibility ratio with frequency ratio for different values of damping. [**RTU 2015, 2017**]

13. A huge machinery is mounted on a bed plate which is supported on four elastic members each having a stiffness of 4000 kN/m. The total weight to be supported is 10 kN. It is estimated that the total damping force exerted on the system is 20% of the critical and is of viscous nature. When the speed of rotation of the machine is 2000 r.p.m., the amplitude of vertical motion of the bed plate is 0.6 mm. Calculate the total maximum force transmitted through each mounting to foundation.

14. A radio set weighing 200 N must be isolated from a machine vibrating with an amplitude of 0.1 mm at 500 c.p.m. The set is mounted on four isolators, each having a spring scale of 32 kN/m and damping coefficient of 400 N-s/m. What is the amplitude of vibration of the radio?

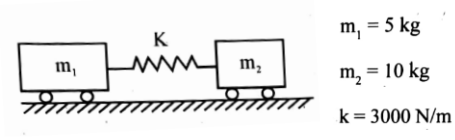
15. Write short notes on various isolation materials [**RTU 2010, 2013**]

16. A radio set of 20 kg mass must be isolated from a machine vibrating with amplitude of 0.05 mm at 500 cpm. The set is mounted on 4 isolators, each having a spring scale of 31400 N/m and damping coefficient of 392 N-s/m. Determine:
    (a) Amplitude of vibration of radio. Ans. = 0.069 mm
    (b) Dynamic load on each isolator due to vibration. Ans. = 0.94 N
    Hint: Dynamic load on isolator is resultant of cwZ_o and kZ_o

TUTORIAL SHEET #3

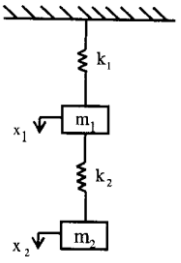
Two degree of Freedom Systems

1. Determine the natural frequencies and mode shapes of the system shown in figure



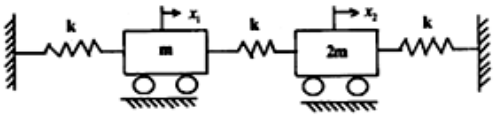
[RTU 2017]

2. Figure shows a vibrating system having two degrees of freedom. Determine the two natural frequencies of vibrations and the ratio of amplitudes of m_1 and m_2 for the two modes of vibration.



[RTU 2016]

3. Figure shows an undamped 2 DOF system. Determine the governing equation for the system, the natural frequencies of the system, the normal modes of the system and nodal points if any.



[RTU 2015]

4. With the help of suitable mathematical derivation, explain the principle of undamped dynamic vibration absorber. **[RTU 2017]**

5. Explain principle & working of centrifugal pendulum absorber. **[RTU 2014, 2016]**

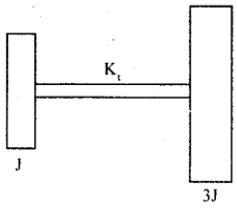
6. A machine runs at 5000 rpm. Its forcing frequency is very near to its natural frequency. If the nearest frequency of the machine is at least 20% from the forced frequency, design a suitable vibration absorber for the system. Assume the mass of the machine as 30 kg. **[RTU 2016]**

7. A gas engine has a mass of 30 kg and runs at a constant speed of 3600 rpm. It vibrates with large amplitude of vibration at operating speed. Design a dynamic vibration absorber to be coupled to the engine so that the nearest resonant frequency of the combined system is at least 25% away from the operating speed. **[RTU 2014]**

8. Discuss the effect of mass ratio on the response frequency ratio for an undamped dynamic vibration absorber. **[RTU 2013]**

9. In a refrigeration plant, a section of pipe carrying refrigerant vibrated violently at a compressor speed of 240 rpm. To eliminate this difficulty, it was proposed to clamp a cantilever spring mass system to the pipe to act as an absorber. In a trial test, a 900 gram absorber tuned to 240 rpm resulted in two natural frequencies of 190 and 270 cpm. If the absorber system is to be designed so that the natural frequencies lie outside the region 160 and 320 cpm, what must be the weight and spring stiffness? **[RTU 2013]**

10. For the following system, derive and determine the equation of motion, natural frequencies of vibration and mode shapes:



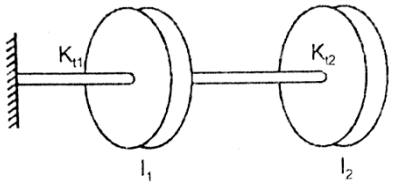
[RTU 2010]

11. A reciprocating engine weighs 400 N and runs at a constant speed of 3000 rpm. After it was installed, it vibrated with large amplitude at the operating speed. What dynamic vibration absorber should be coupled to the system if the nearest resonant frequency of the combined system should be at least 25% away from the operating speed. Under these conditions, what amplitude of the absorber will be obtained?

12. A rotor has a mass of 10 kg mounted midway on a 24 mm diameter horizontal shaft supported at the ends by two short bearings which are 1m apart. The shaft rotates at 2400 rpm. If the center of mass of the rotor is 0.12 mm away from the geometric center of the rotor due to certain manufacturing defects, find the amplitude of steady state vibrations and dynamic force transmitted to the bearings. Also find the critical speed. Take E = 200 GN/m^2. **[RTU 2017]**

13. A vertical steel shaft of 12 mm diameter is held in long bearings 1 m apart and carries at its middle a disc of mass 12 kg. The eccentricity of the center of gravity of the disc from the center of the rotor is 0.3 mm. The modulus of Elasticity of the shaft material is 200 GN/m^2 and the permissible stress is 70 MN/m^2. Find: (i) The critical speed of the shaft and (ii) The range of speed over which it is unsafe to run the shaft. Neglect the mass of the shaft. **[RTU 2015]**

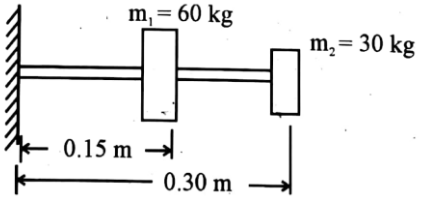
14. Determine the natural frequencies and normal modes of the torsional system shown in figure. Draw the mode shapes and find nodal points if any. Given: $\mathbf{K_{t1}}$ = 10 N-m/rad, $\mathbf{K_{t2}}$ = 20 N-m/rad, $\mathbf{I_1}$ = 5 kg-m^2, $\mathbf{I_2}$ = 10 kg-m^2.



TUTORIAL SHEET #4

Many Degrees of Freedom Systems

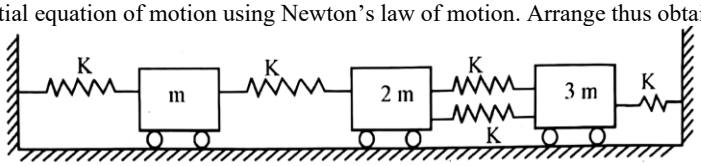
1. (a) Find the lowest natural frequency of the system shown in figure using (i) Dunkerley's method, (ii) Rayleigh's method and (iii) Stodola's method. Compare their results. Take $E = 2 \times 10^{11}$ N/m^2 and cross section moment of inertia of the beam $I = 4 \times 10^{-7}$ m^4.



[RTU 2017]

1. (b) Discuss Rayleigh-Ritz method along with an example.

2. Draw the free body diagram of each of the mass shown in the following many degrees of freedom system shown in figure. Derive the governing differential equation of motion using Newton's law of motion. Arrange thus obtained equations in matrix form.

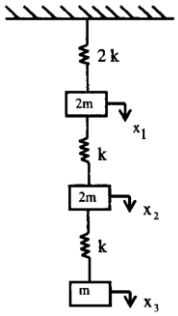


[RTU 2017]

3. Derive the governing equation of motion for the torsional vibration of a shaft. Obtain the frequency equation and mode shapes for the shaft fixed at one end while free at the other end. **[RTU 2017]**

4. Write short notes on Stodola's method. **[RTU 2016]**

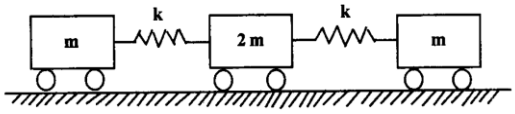
5. Using matrix method, determine the natural frequencies of the system shown in figure.



[RTU 2016]

6. Derive governing equation for the torsional vibration of a shaft fixed at both ends. Find the frequency equation and mode shapes for the same. **[RTU 2016]**

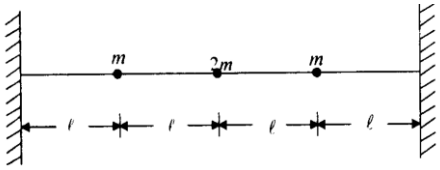
7. Determine the natural frequencies and plot the mode shapes for the three rail bogies connected through coupler springs as shown in figure. Given: **m** = 15 x 10^3 kg; **k** = 30 x 10^5 N/m.



[RTU 2015]

8. Derive the governing equation of vibration for a tightly stretched string with tension **P**. Obtain the frequency equation and mode shapes for the case when one end of the string is fixed while the other end is attached to a roller free to move vertically in a slot. **[RTU 2015]**

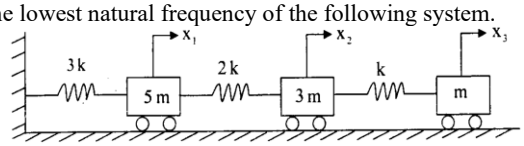
9. For the taut string having tension T and three concentrated masses as shown in figure, use the method of influence numbers to find the three natural frequencies.



[RTU 2014]

10. Derive the governing equation for transverse vibrations of a tightly stretched elastic string fixed at both ends. Using method of separation of variables, obtain the frequency equation and mode shapes for the same. Plot the first four modes. **[RTU 2014]**

11. Using Stodola's method, find the lowest natural frequency of the following system.



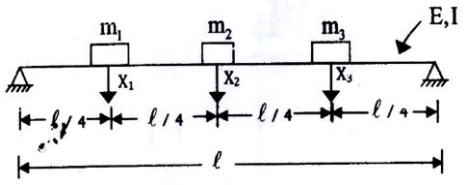
[RTU 2014]

12. Determine all the eigen values and corresponding eigen vectors of a vibrating system for which mass and stiffness matrices are given below.

$$[m] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix}; \quad [k] = \begin{bmatrix} 1 & -2 & 1 \\ -2 & 4 & -2 \\ 1 & -2 & 1 \end{bmatrix}$$

[RTU 2013]

13. Estimate the fundamental natural frequency of a simply supported beam carrying three identical equally spaced masses (shown in figure below) using Dunkerley's formula. $m_1 = m_2 = m_3 = m$.



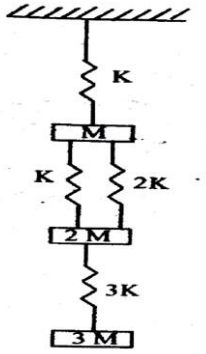
[RTU 2013]

14. Derive the equation governing the free torsional vibration of a uniform homogeneous rod. Also find the first three natural frequencies and corresponding mode shapes for fixed-fixed end conditions. **[RTU 2013, 2012]**

15. With the help of an example illustrate the use of influence coefficients and Maxwell's reciprocal theorem in finding natural frequency of a system. **[RTU 2012]**

16. Write a short note on Holzer's method. **[RTU 2012]**

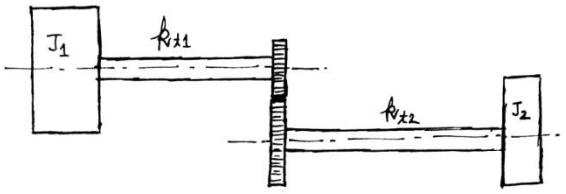
17. Find the frequency equation of the system shown in figure:



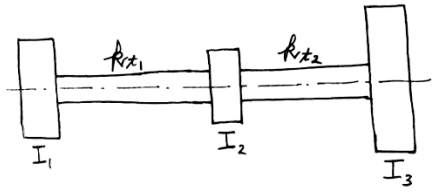
[RTU 2011]

18. Derive the governing equation of free longitudinal vibration of a uniform bar fixed at one end. Find the frequency equation and mode shapes for the same. **[RTU 2011]**

19. In the arrangement shown in figure below, If the moments of inertia of the gears are negligible and $J_1 = 2J_2$; $k_{t1} = k_{t2} = k_t$, and gear reduction ratio n = 3, determine the frequency of torsional vibrations.



20. Determine the natural frequencies, mode shapes and nodal points for a three degree of freedom torsional system shown in figure below. Take $I_1 = 2$ kg-m^2, $I_2 = 1$ kg-m^2, $I_3 = 3$ kg-m^2, $k_{t1} = 5$ N-m/rad, $k_{t2} = 10$ N-m/rad.



Tutorial Sheet # 5

Unit1: Introduction to Sound, Noise and vibration

1. What is Noise? On what parameters it is being measured?
2. What do you understand by sound pressure dependent human response and frequency dependent human response? **(RTU 2010, 2011, 2013, 2017)**
3. Define sound pressure level and sound intensity level and derive the relationship between sound pressure level and sound intensity level. **(RTU 2017)**
4. Define sound power level and sound intensity level Derive the relationship between sound power level and sound intensity level. **(RTU 2010)**
5. Derive an equation for finding out sound intensity at a distance r from the source of sound of known sound power level. **(RTU 2010, 2016)**
6. What is meant by frequency based hearing sensitivity? What are the usual audible frequency range and frequency range of human voice? **(RTU 2015)**
7. Discuss various methods used in controlling industrial noise. **(RTU 2012, 2016)**
8. What are the auditory and non-auditory effects of noise? **(RTU 2013, 2014, 2015, 2016)**
9. Explain term loudness. How does it vary with the frequency? How this variation is taken in account in the subjective assessment. **(RTU 2016)**
10. What are the major noise sources in urban environment? **(RTU 2015)**
11. Enlist the major noise sources in industrial environment. What control measures can be adopted for noise control? **(RTU 2010 2013, 2014, 2017)**
12. Explain the following terms:
    - (i) Sound spectra **(RTU 2012, 2014)**
    - (ii) Octave band analysis **(RTU 2011, 2012, 2014)**
    - (iii) Loudness **(RTU 2012)**
    - (iv) Noise standards and limits **(RTU 2012)**
    - (v) Masking
13. A machine operator in a factory surrounded by five machines. The machines produce 95 dB, 87 dB, 90 dB, 93dB and 88 dB respectively at the operator position, when there is no background noise. When the machines are off, the SPL at his position is 88 dB. Determine the total SPL at his position due to both the machines and the ambient sound. **(RTU 2014)**

14. A diesel powered heavy Truck has the noise source with SPL in presence of background noise as: Exhaust 98dB, Fan 88dB, Engine 83 dB, Air intake 75dB. When the truck is turned off the SPL at the same place is 70dB. Determine the total SPL of the truck independent of the background noise. **(RTU 2013)**

15. The noise level measured at a particular location in a factory with a noisy machine operating nearby is 92 dB. When the machine is turned off, the noise level measured at the same location is 88 dB. What is the level due to the machine alone?

16. Write short notes on following:
    (i) Acoustic barriers
    (ii) Noise enclosures
    (iii) Mufflers and sifencers
    (iv) Adaptive noise control

17. An enclosure wall of surface area 10 m^2 constructed from a material having transmission loss (TL) of 30 dB. Calculate the resultant transmission loss if a panel of area 3 m^2 is introduced on the wall. The TL of panel material is 10 dB.

18. Write a note on useful applications and harmful effects of vibrations.

19. Classify the vibrations on basis of applied force, damping, periodicity and stress induced in vibrating body.

20. For complex number $Z_1 = (1+2i)$ and $Z_2 = (3 - 4i)$ determine the ratio Z_1/Z_2 and express the result in the form of $Ae^{i\theta}$. **(RTU 2017)**

21. A machine is subjected to the motion $x(t) = A\cos(50t + \varphi)$ mm. The initial conditions are $x(0) = 3$ and $v(0) = 1\ m/s$ find the constants A and φ. **(RTU 2013)**

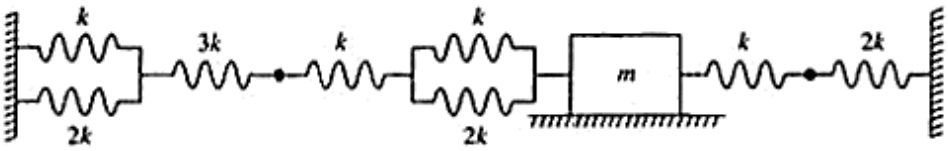
TUTORIAL SHEET #1

1. Describe the following terms in context of vibrations:
(i) Natural Frequency (ii) Resonance (iii) Simple Harmonic motion (iv) Phase angle

2. What do you understand by center of percussion? Explain its role in designing various engineering applications. [RTU 2009]

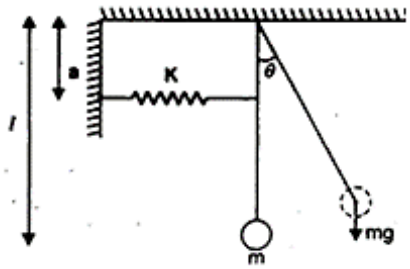
3. The displacement vector of a vibrating body is given by: $x = 5\sin(31.41t + \frac{\pi}{4})$. Determine the displacement, velocity and acceleration after 0.11 second. Also determine the frequency of vibration.

4. Find the natural frequency of the spring-mass system shown in figure below. Assume frictional resistance to be zero.

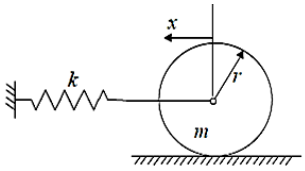


5. A spring-mass system k_1, m_1 has a natural frequency f_1. Calculate the value of k_2, another spring which when connected to k_1 in series decreases the frequency by 20%. [RTU 2017]

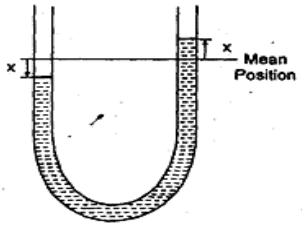
6. Determine the natural frequency of vibrations for the spring pendulum as shown in figure below. [RU 2003]



7. A circular cylinder of mass 4 kg and radius 12 cm is connected by a spring of stiffness 6000 N/m as shown in figure. If it is free to roll on horizontal rough surface without slipping. Determine the natural frequency. [RTU 2017]

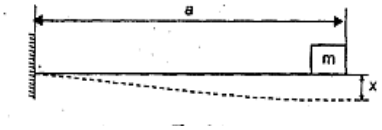


8. Calculate the natural frequency of vibration for the column of liquid in a simple U-Tube manometer as shown in figure below. Take length of tube as 0.2 m. [RU 2003]



9. Derive the frequency equation for a compound pendulum. Explain the importance of center of percussion. [RTU 2015]

10. A cantilever beam of negligible mass is loaded with mass 'm' at the free end as shown in figure below. Find the natural frequency of vibration. Take 'E' as the modulus of elasticity of the beam material, and 'I' as the area moment of inertia of beam cross-section about the neutral axis.



11. A shaft supported freely at the ends has a mass of 100 kg placed 25 cm from one end. Find the frequency of the natural transverse vibrations if the length of the shaft is 75 cm, E = 200 GN/m^2 and shaft diameter is 4 cm. [RTU 2016]

12. A torsional pendulum consists of a disc type rotor of mass 2 kg and diameter 0.2 m at the lower end supported by a rod of diameter 5 mm and length 1 m. The modulus of rigidity of the rod material may be assumed to be 83 GPa. Calculate the natural frequency of torsional vibrations.

13. Explain the salient characteristics of a coulomb damped system. How is it different from a viscous damped system? Also derive the equation governing the vibration of a coulomb damped spring-mass system. [RTU 2013]

14. What do you understand by under-damped system, over-damped system and Critically damped systems? Explain with examples. [RTU 2016]

15. The natural frequency of an undamped vibrating system is 100 rad/s. A damper with a damping factor of 0.8 is introduced into the system. Determine the frequency of vibration of the damped system in rad/s. [GATE-2000]

16. A vibrating system is defined by following parameters:
m = 3 kg, k = 100 N/m, c = 3 N sec/m.
Determine the damping factor, frequency of damped vibration and logarithmic decrement.
[RTU 2010 & 2017]

17. A torsional pendulum when immersed in oil indicates its damped natural frequency as 200 Hz. But when it was put to vibration in vacuum having no damping, its natural frequency was observed as 250 Hz. Find the value of damping factor of oil.