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PTQ

Prelims Through Questions

for

ESE 2021

Mechanical Engineering

Day 7 of 11

Q.271 - Q.320

(Out of 500 Questions)

Industrial Engg. + Fluid Mechanics + Fluid Machinery

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Q.271 Consider the following statements :

1. The condition of no slip at rigid boundaries is applicable to flow of Newtonian fluids only.
2. The Mohr circle for fluid element inside the fluid body at rest is point on shear stress axis.
3. Aneroid barometer measures local atmospheric pressure.

Which of the above statements are incorrect?

(a) 1, 2 and 3 (b) 2 and 3
(c) 1 and 3 (d) 1 and 2

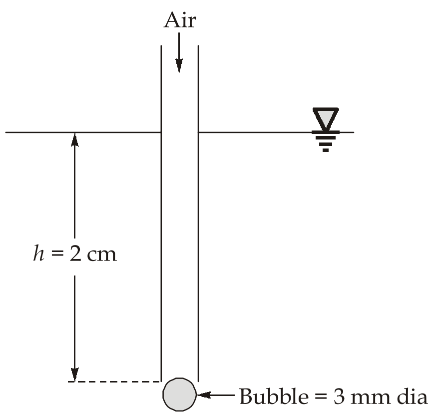
271. (d)

1. No slip condition is applicable to flow of all real fluids.
2. The Mohr circle for fluid element inside the fluid body at rest is point on normal stress axis.

Q.272 A glass tube having internal diameter of 3.0 mm is immersed in a liquid of specific gravity 0.80 upto the depth of 2 cm. Air is forced into the tube from upper end to form a spherical bubble at the lower end of tube. If the air pressure inside the bubble is 210 N/m^2, then what is the surface tension of the liquid? (Take g = 10 m/s^2).

(a) 0.01575 N/m (b) 0.0375 N/m
(c) 0.02175 N/m (d) 0.075 N/m

272. (b)



Pressure inside the bubble, $P_i = 210 \text{ N/m}^2$

Internal diameter of tube, $d_{tube} = 3 \text{ mm} = 3 \times 10^{-3} \text{ m}$

Diameter of bubble should be same as diameter of tube.

$\therefore \quad d_{bubble} = d_{tube} = 3 \times 10^{-3} \text{ m}$

Density of fluid = (Specific gravity) × 1000 = 0.80 × 1000 = 800 kg/m^3

Pressure outside the bubble, $P_o = \rho g h$

$$= 800 \times 10 \times \frac{2}{100}$$

$$= 160 \text{ N/m}^2$$

Difference in pressure, $\Delta P = P_i - P_o = (210 - 160) \text{ N/m}^2 = 50 \text{ N/m}^2$

We know that for a bubble, $$\Delta P = \frac{4\sigma}{d_{bubble}} = \frac{4\sigma}{3\times10^{-3}}$$

$$50 = \frac{4\sigma}{3\times10^{-3}}$$

$$\sigma = \frac{0.150}{4} = 0.0375 \text{ N/m}$$

Q.273 A balloon containing hot air is used to lift a combined load of basket and the goods inside it. The magnitude of combined load is 4312 N. Assume that the balloon can be approximated as a sphere of diameter 14 m. What will be the value of density of hot air inside the balloon if the density of atmospheric air is 1.3 kg/m^3? (Take g = 10 m/s^2).

(a) 0.8 kg/m^3 (b) 1 kg/m^3

(c) 1.2 kg/m^3 (d) 1.25 kg/m^3

273. (b)

Volume of balloon, $$V = \frac{\pi d^3}{6} = \frac{\pi(14)^3}{6}$$

The forces acting on the balloon in vertical direction are :

1. Weight (combined load) of basket and goods (downward)
2. Weight of hot air inside the balloon (downward)
3. Buoyancy force (upward)

Now $$\Sigma F_y = 0$$

$$F_{buoyancy} - W_{hot\ air} - W_{basket} = 0$$

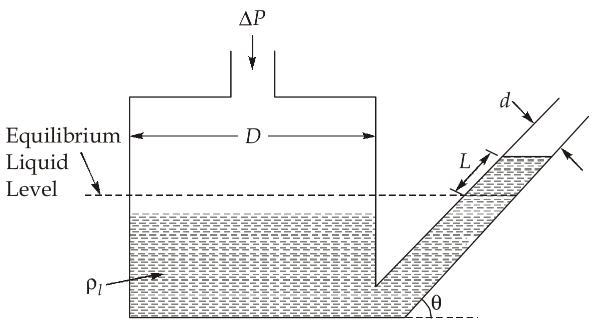
$$\rho_{atm} gV - \rho_{hot\ air} gV - 4312 = 0$$

$$\rho_{hot\ air} = \rho_{atm} - \frac{4312}{gV} = 1.3 - \frac{6\times4312}{10\times\pi(14)^3}$$

$$= 1.3 - \frac{6\times4312\times7}{10\times22\times14\times14^2} = 1.3 - \frac{6\times14^2\times22}{10\times22\times2\times14^2}$$

$$= 1.3 - 0.3 = 1 \text{ kg/m}^3$$

Q.274 An inclined-tube reservoir manometer is constructed as shown below.

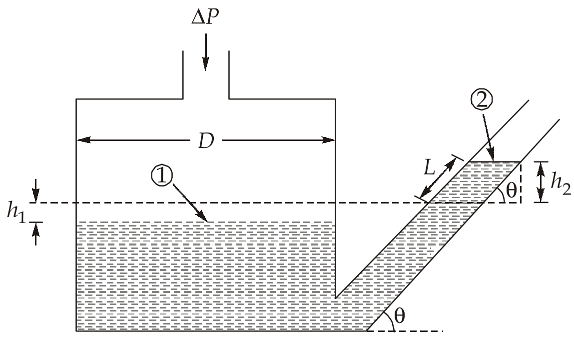


If ρ_l is the density of gauge liquid and g is acceleration due to gravity, then which one of the following option is correct?

(a) $L = \dfrac{\Delta P}{\rho_l g\left[\sin^2\theta + \left(\dfrac{D}{d}\right)^2\right]}$ (b) $L = \dfrac{\Delta P}{\rho_l g\left[\sin^2\theta + \left(\dfrac{d}{D}\right)\right]}$

(c) $L = \dfrac{\Delta P}{\rho_l g\left[\sin\theta + \left(\dfrac{D}{d}\right)^2\right]}$ (d) $L = \dfrac{\Delta P}{\rho_l g\left[\sin\theta + \left(\dfrac{d}{D}\right)^2\right]}$

274. (d)



Assume static and incompressible fluid.

By hydrostatic law, between (1) and (2),

$$P_1 - P_2 = \Delta P = \rho_l g(h_1 + h_2) \quad ...(1)$$

Since volume of manometer liquid is constant.

∴ Volume displaced from reservoir = Volume that rises in the tube

$$\frac{\pi}{4}D^2 h_1 = \frac{\pi d^2}{4}L$$

$$h_1 = L\left(\frac{d}{D}\right)^2 \quad ...(2)$$

and $h_2 = L\sin\theta$ ...(3) (from geometry of manometer)

From (1), (2) and (3)

$$\Delta P = \rho_l g\left[L\sin\theta + L\left(\frac{d}{D}\right)^2\right]$$

$$L = \frac{\Delta P}{\rho_l g\left[\sin\theta + \left(\dfrac{d}{D}\right)^2\right]}$$

Q.275 Consider the velocity potential function $\phi = 2(x^2 + 2y - y^2)$, describes the possible flow of an incompressible fluid. Which of the following option represents the equation of streamline at (1, 2)?

(a) $2y - x = 3$ (b) $y - 2x = 0$

(c) $y - x = 1$ (d) $y + x = 3$

275. (c)

Given,

$$\phi = 2(x^2 + 2y - y^2)$$

$$u = \frac{\partial \phi}{\partial x} = 4x$$

$$v = \frac{\partial \phi}{\partial y} = 4 - 4y$$

Equation of streamline,

$$\frac{dy}{v} = \frac{dx}{u}$$

$$\frac{dy}{4-4y} = \frac{dx}{4x}$$

$$\frac{dy}{(1-y)} = \frac{dx}{x}$$

Integrating, we get,

$$\ln(1 - y) = \ln x + \ln c$$

$$\ln(1 - y) = \ln (xc)$$

$$1 - y = (x)(c)$$

At (1, 2),

$$1 - 2 = c \Rightarrow \quad c = -1$$

$\therefore$

$$1 - y = -x$$

$$y - x = 1$$

Q.276 Consider the following statements:

1. A streakline is an instantaneous snapshot of a time-integrated flow pattern.
2. A pathline is the time exposed flow path of an individual particle at a particular instant of time.
3. Streamline represents an instantaneous flow pattern while a streakline has some time history associated with it.
4. If the flow is steady, streamlines, pathlines, and streaklines are identical.

Which of the above statements are correct?

(a) 2, 3 and 4
(b) 1, 2, 3 and 4
(c) 1, 2 and 4
(d) 1, 3 and 4

276. (d)

A pathline is a time exposed flow path of an individual particle over some time period.

Q.277 A venturimeter has a differential mercury water manometer connected to its inlet and throat. The gauge reading y of the manometer for a given discharge in the pipe:

(a) depends on the orientation of venturimeter
(b) is independent of the orientation of venturimeter
(c) varies as the slope of the venturimeter with respect to the horizontal
(d) depends on whether the manometer is above or below the pipe centre line.

277. (b)

$$\Delta h = y\left(\frac{S_m}{S_p} - 1\right)$$

S_m = relative density of manometric fluid
S_p = relative density of fluid flowing in pipe

From above equation we can say that the Δh depends on gauge reading y regardless of the orientation of the venturimeter.

Q.278 Consider the following statements :

1. In laminar flow between two fixed parallel plates, the shear stress is maximum at the boundary and zero at the centre.
2. The separation of boundary layer takes place when the pressure gradient is positive and shear stress is maximum.
3. Darcy-Weisbach friction factor value is more in case of turbulent flow as compared to laminar flow.

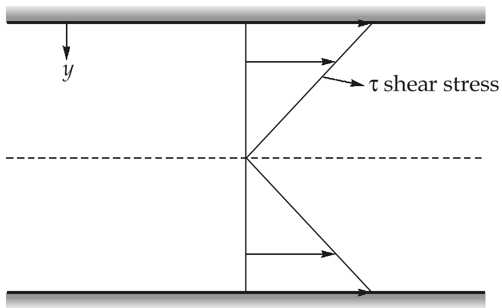
Which of the above statements is(are) correct?

(a) 1 only
(b) 1 and 2
(c) 2 and 3
(d) 1 and 3

278. (d)

1. Shear stress variation for flow between two parallel plate is linear with maximum at boundary and zero at centre

$$\tau = \tau_0\left(\frac{y}{B/2} - 1\right)$$



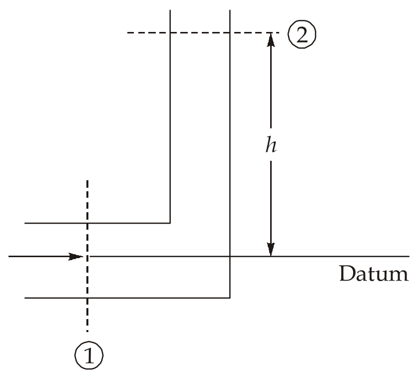
At $y = B/2$, $\tau = 0$, i.e., at centre.

2. The separation of boundary layer takes place when pressure gradient is positive and shear stress is zero as velocity gradient is also zero.
3. The intense mixing of fluid in turbulent flow as a result of rapid fluctuation enhances momentum transfer between fluid particles, which increases the friction force on pipewall. The friction factor reaches a maximum when flow becomes turbulent.

Q.279 Water at 120 kPa (gauge) is flowing in a horizontal pipe at a velocity of 5 m/s. The pipe makes 90° angle at the exit and the water exits the pipe vertically into the air. The total head loss due to friction in the pipe is 2 m and the loss of head due to bend of 90° is given as 0.8 m. What is the maximum height that the jet can rise? (Take g = 10 m/s^2)

(a) 9.45 m (b) 8.45 m
(c) 11.25 m (d) 10.45 m

279. (d)



$$P_2 = P_{atm}$$

$(P_{gauge})_1$ = 120 kPa (atmospheric pressure is already included in gauge)

$$\therefore \quad (P_1 - P_2) = 120 \text{ kPa}$$

$$V_1 = 5 \text{ m/s}$$

For maximum height at 2, $V_2 = 0$

Applying equation between section (1) and (2)

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + h_f + h_{bend}$$

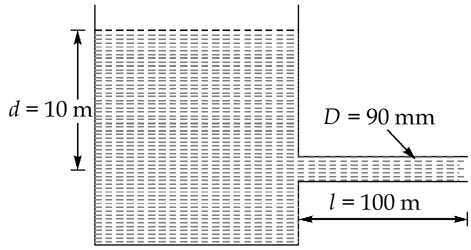
$$\left(\frac{P_1 - P_2}{\rho g}\right) + \frac{V_1^2}{2g} - \frac{V_2^2}{2g} - h_f - h_{\text{bend}} = (Z_2 - Z_1) = h$$

$$\frac{120 \times 10^3}{1000 \times 10} + \frac{5^2}{2 \times 10} - 2 - 0.8 = h$$

$$12 + 1.25 - 2 - 0.8 = h$$

$$\therefore \quad h = 10.45 \text{ m}$$

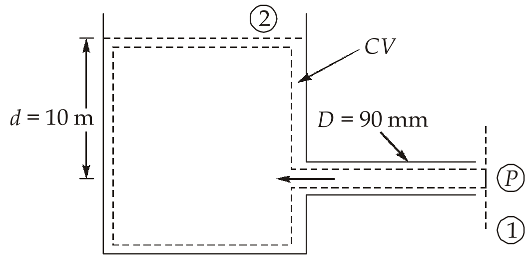
Q.280 There is a smooth horizontal pipe, one end of which is connected to a large reservoir and other end is connected to a pump which is used to pump water into the reservoir at a constant velocity of 3 m/s. The length and the diameter of pipe is 100 m and 90 mm respectively. Take friction factor, f as 0.01. What pressure (gauge) must the pump produce at the pipe to generate this velocity (Considering exit minor loss also)?



(a) 146 kPa
(b) 145 kPa
(c) 148 kPa
(d) 150 kPa

280. (c)

Given : $l = 100$ m, $D = 90$ mm $= 0.090$ m, $f = 0.01$, $V = 3$ m/s



Applying energy equation between (1) and (2)

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + h_f + h_e$$

$$\left(\frac{P_1 - P_2}{\rho g}\right) + \frac{V^2}{2g} = 0 + (Z_2 - Z_1) + \frac{flV^2}{2gD} + \frac{V^2}{2g}$$

$\left(h_f = \frac{flV^2}{2gD}, h_e = \text{exit loss} = \frac{V^2}{2g} \text{ and } V_2 = 0\right)$

$$\frac{P_{\text{gauge}}}{\rho g} = d + \frac{flV^2}{2gD} \Rightarrow \Delta P = \rho\left[gd + f\frac{l}{D}\frac{V^2}{2}\right]$$

$$\Delta P = 1000\left[9.81 \times 10 + \frac{0.01 \times 100 \times 3^2}{2 \times 0.090}\right]$$

$$P_a = 1000\left[98.1 + \frac{9}{2 \times 0.09}\right]$$

$$= 1000(98.1 + 50) = 148.1 \times 1000 \text{ Pa}$$

$$P_{(\text{gauge})} = 148.1 \text{ kPa}$$

Q.281 The drag coefficient on an aircraft is reduced by 48.8%. If the power to overcome aerodynamic drag of an aircraft remains the same then what is the percentage change in velocity?
(a) 20% decrease (b) 25% decrease
(c) 20% increase (d) 25% increase

281. (d)

Drag force, $F_D = \frac{1}{2} C_D \rho A V^2$

where C_D = Drag coefficient, ρ = Density, A = Projected area, V = Velocity

Power, $P = F_D V = \frac{1}{2} C_D \rho A V^2 \cdot V$

$$P = \frac{C_D \rho A V^3}{2}$$

As given in question, P = Constant, and we can assume ρ and A to be constant.

$$\therefore \quad C_D V^3 = \text{Constant}$$

$$C_{D1} V_1^3 = C_{D2} V_2^3$$

Now, $C_{D_2} = 0.512 C_{D_1}$ (as 48.8% reduction)

$$C_{D_1} V_1^3 = 0.512 C_{D_1} V_2^3$$

$$\left(\frac{V_2}{V_1}\right) = \left(\frac{1}{0.512}\right)^{1/3} = \frac{1}{0.8} = \frac{5}{4} = 1.25$$

$$V_2 = 1.25 V_1$$

$\therefore$ 25% increase in velocity.

Q.282 In a uniform laminar flow between two stationary parallel plates separated by a distance of 8 mm, the centre line velocity is 2.5 m/s.
What will be the velocity at a distance of 2 mm from the boundary?
(a) 2 m/s (b) 1.81 m/s
(c) 1.75 m/s (d) 1.87 m/s

282. (d)

For the laminar flow between two parallel stationary plate the velocity distribution is given by

$$V = V_m\left[2\left(\frac{y}{B/2}\right) - \left(\frac{y}{B/2}\right)^2\right]$$

B = Distance between the plates = 8 mm
V_m = Centre line or maximum velocity = 2.5 m/s
y = Distance from the boundary = 2 mm

$$\therefore \quad V = 2.5\left[2\left(\frac{2}{8/2}\right) - \left(\frac{2}{8/2}\right)^2\right]$$

$$= 2.5\left[\frac{4}{4} - \left(\frac{2}{4}\right)^2\right] = 2.5(1 - 0.5^2)$$

$$= 2.5 \times (1 - 0.25) = 2.5(0.75)$$

$$V = 1.875 \text{ m/s}$$

Q.283 Consider the following statements regarding Buckingham's Pi-Theorem:

1. The repeating variables must include among them all the fundamental dimensions necessarily in each one.
2. The dependent or the output parameter of the physical phenomenon should be included in the repeating variable.

Which of the above statement(s) is/are correct?

(a) Both 1 and 2
(b) Only 1
(c) Only 2
(d) Neither 1 nor 2

283. (d)

Both statements are incorrect. The correct statements are as :

1. The repeating variables must include among them all the fundamental dimensions, not necessarily in each one but collectively.
2. The dependent variable or the output parameter of the physical phenomenon should not be included in the repeating variables.

Q.284 Considers the following statements regarding the specific speed of a Pelton wheel.

1. The specific speed of a Pelton wheel depends on the ratio of jet diameter d and the wheel pitch diameter D (the diameter at the centre of the bucket).
2. A small value of D/d reduces the rpm as well as the mechanical efficiency of the wheel.
3. The optimum value of the overall efficiency of a Pelton turbine depends on the specific speed and the speed ratio both.
4. The Pelton wheels with a single jet operate in the specific speed range of (4-16).

Which of the above statements are correct?

(a) 2 and 3 only
(b) 1, 2, and 4 only
(c) 1, 3 and 4 only
(d) 1, 2, 3 and 4

284. (c)

The specific speed of a Pelton wheel depends on the ratio of jet diameter d and the wheel pitch diameter, D (the diameter at the centre of the bucket). If the hydraulic efficiency of a Pelton wheel is defined as the ratio of the power delivered (P) to the wheel to the head available H at the nozzle entrance, then we can write :

$$\text{Hydraulic power, } P = \rho Q g H \eta_h = \frac{\pi \rho d^2 V_1^3 \eta_h}{4 \times 2C_v^2} \quad \text{...(1)}$$

Since $$Q = \frac{\pi d^2}{4} V_1 \text{ and } V_1 = C_v (2gH)^{1/2}$$

The specific speed, $N_{ST} = \dfrac{NP^{1/2}}{H^{5/4}}$

- The optimum value of the overall efficiency of a Pelton turbine depends both on the values of the specific speed and the speed ratio.
- The Pelton wheels with a single jet operate in the specific speed range of 4-16, and therefore the ratio D/d lies between 6 to 26.
- A large value of D/d reduces the rpm as well as the mechanical efficiency of the wheel. It is possible to increase the specific speed by choosing a lower value of D/d, but the efficiency will decrease because of the close spacing of buckets.
- The value of D/d is normally kept between 14 and 16 to maintain high efficiency.

Q.285 What will be the type of turbine; if a hydraulic turbine has an output of 6600 kW when it works under a head of 25 m and runs at 100 rpm? (Assume $25^{5/4} = 55.9$)

(a) Pelton turbine
(b) Francis turbine
(c) Kaplan turbine
(d) None of these

285. (b)

As per given data :

$$P = 6600 \text{ kW} \qquad H = 25 \text{ m}, \ N = 100 \text{ rpm}$$

$$N_{ST} = \frac{N\sqrt{P}}{H^{5/4}} = \frac{100\sqrt{6600}}{25^{5/4}}$$

$$= \frac{100 \times 10\sqrt{66}}{25^{5/4}} = 145.33$$

In this case, since $50 < N_S < 400$, it can be a Francis turbine.

Q.286 For a radial vanes impeller, the theoretical head in case of a centrifugal pump :

(a) increases with discharge
(b) decreases with discharge
(c) remains independent of discharge
(d) first increases then decreases with discharge

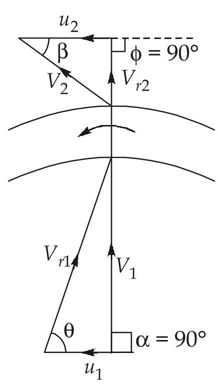
286. (c)

As we know:

$$V_{w2} = u_2 - V_{f2} \cot\phi$$

$$\text{Discharge, } Q = \pi D_2 B_2 V_{f2}$$

$$V_{f2} = \frac{Q}{\pi D_2 B_2}$$



So,
$$V_{w2} = u_2 - \frac{Q}{\pi D_2 B_2}\cot\phi$$

$$\text{Head, } H = \frac{V_{w2}u_2}{g} = \left(u_2 - \frac{Q}{\pi D_2 B_2}\cot\phi\right)\frac{u_2}{g}$$

$$= \frac{u_2^2}{g} - \frac{u_2 \times Q}{\pi D_2 B_2}\cot\phi$$

For radial vane, $\phi = 90°$

$$\text{Then, } H = \frac{u_2^2}{g}$$

So, theoretical head $= \dfrac{u_2^2}{g}$ which is independent from discharge.

Q.287 A jet of water moving at 20 m/s impinges on a symmetrical curved vane shaped to deflect the jet through 120° (that is the vane angle at inlet and outlet equal to 30° each). If the vane is moving at 5 m/s, so what should be the angle of jet in order to generate no shock at inlet? (Assume $\sin^{-1}(0.125) = 7.18°$)

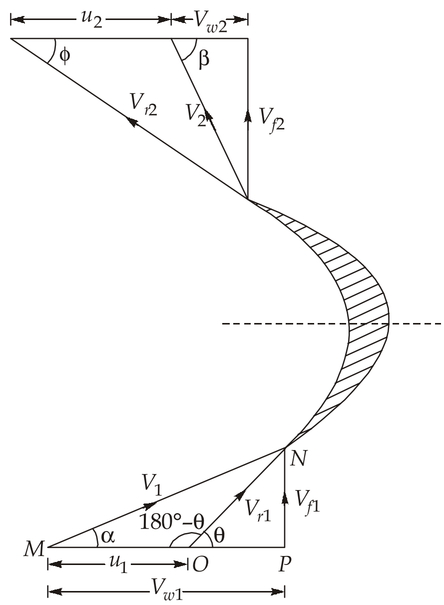
(a) 37.18° (b) 20.72°
(c) 16.70° (d) 22.82°

287. (d)

As per the given information :

$$V_1 = 20 \text{ m/s}$$
$$\theta = 30°$$
$$u_1 = u_2 = u = 5 \text{ m/s}$$

From the velocity triangle at inlet ∠MON



$$\frac{V_1}{\sin(180° - \theta)} = \frac{u_1}{\sin(\theta - \alpha)}$$
$$\frac{20}{\sin(180° - \theta)} = \frac{5}{\sin(30 - \alpha)}$$
$$\Rightarrow \quad \frac{20}{\sin\theta} = \frac{5}{\sin(30 - \alpha)}$$
$$\sin(30° - \alpha) = \frac{1}{2} \times \frac{1}{4} = 0.125$$
$$30° - \alpha = \sin^{-1}(0.125) = 7.18°$$
$$\alpha = 30° - 7.18°$$
$$\alpha = 22.82°$$

Q.288 A single acting reciprocating pump has a bore of 25 cm and stroke of 40 cm, runs at 30 rpm. It discharges water at the rate of 0.009 m^3/s. The suction and delivery heads are 7 m and 15 m respectively. The percentage slip will be in the range of :

(a) 1 to 3% (b) 4 to 6%
(c) 8 to 10% (d) 11 to 13%

288. (c)

According to the given data : $A = \frac{\pi}{4} \times 0.25^2$; $L = 0.40$ m; $N = 30$ rpm

$$Q_{act} = 0.009 \text{ m}^3/\text{s};\ H_s = 7 \text{ m};\ H_d = 15 \text{ m}$$

% of Slip,

$$\text{Slip} = \frac{(Q_{th} - Q_{act}) \times 100}{Q_{th}}$$
$$Q_{th} = \frac{ALN}{60} = \frac{\frac{\pi}{4} \times 0.25^2 \times 0.4 \times 30}{60} \text{ m}^3/\text{s}$$
$$Q_{th} = 0.009817 \text{ m}^3/\text{s}$$
$$\text{Slip} = \left|\frac{0.009817 - 0.009}{0.009817}\right| \times 100$$
$$= 8.322\%$$

Q.289 Choose the incorrect statement among the following regarding fluid machinery system:

(a) The energy stored by a fluid mass appears in the form of potential, kinetic and intermolecular energy.

(b) Machines using liquid (mainly water, for almost all practical purposes) are termed as hydraulic machines.

(c) The device in which the kinetic, potential or intermolecular energy held by the fluid is converted in the form of mechanical energy by a rotating member is known as a pump.

(d) In compressor, fans or blower, the mechanical energy from moving parts is transferred to a fluid to increase its stored energy by increasing either its pressure or velocities.

289. (c)

The device in which the kinetic, potential or intermolecular energy held by the fluid is converted in the form of mechanical energy by a rotating member is known as a turbine.

Q.290 For a project, the critical path standard deviation must be less than 2. The critical path consists of four activities with variances of three activities to be $\frac{1}{9}, \frac{4}{9}$ and 1. What could be the maximum possible standard deviation for the fourth activity?

(a) 1.56 (b) 2.44

(c) 0.44 (d) 0.20

290. (a)

For critical path,

Variance of critical path = Sum of variances of critical path activities

$$(2)^2 = \frac{1}{9} + \frac{4}{9} + 1 + V_4 \quad (\because \text{Standard deviation, } \sigma = \sqrt{\text{Variance}})$$

$$4 - \left(\frac{14}{9}\right) = V_4$$

$$V_4 = \frac{22}{9}$$

$$\text{Standard deviation, } \sigma_4 = \sqrt{V_4} = \sqrt{\frac{22}{9}} = 1.5634$$

Q.291 MRP system needs data from:

1. Master production schedule
2. Inventory status file
3. Bill of material

Select the correct answer using the codes given below:

(a) 1 and 2 (b) Only 1

(c) 2 and 3 (d) 1, 2 and 3

291. (d)

Q.292 Consider the following statements:

1. PERT is probabilistic model.
2. CPM is deterministic model.
3. Critical path activities may have non zero slack.

Select the incorrect statements using the codes given below:

(a) 1 and 2 (b) Only 3
(c) 1, 2 and 3 (d) None of the statements

292. (b)

Slack is the amount of time that an activity can be delayed past its earliest start or earliest finish without delaying the project. The critical path is the path through the project network in which none of the activities have slack, that is, the path for which ES = LS and EF = LF for all activities in the path. Therefore statement 3 is incorrect.

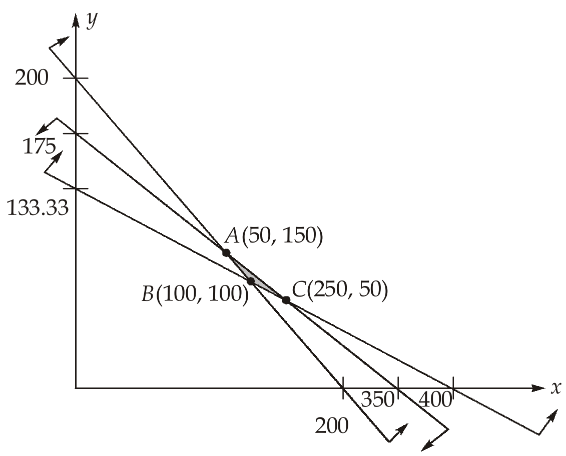
Q.293 Minimize objective function, $z = 2x + 4y$

Subjected to,
$$x + y \geq 200$$
$$x + 3y \geq 400$$
$$x + 2y \leq 350$$

What will be the minimum value of objective function?

(a) 500 (b) 600
(c) 700 (d) 550

293. (b)



ABC is feasible region

$$z(A) = 2 \times 50 + 4 \times 150 = 700$$
$$z(B) = 2 \times 100 + 4 \times 100 = 600$$
$$z(C) = 2 \times 250 + 4 \times 50 = 700$$

So, the minimum value will be at B.

Q.294 A machine operator has to perform two operations, turning and then threading on different jobs. The time required to perform these operations (in minutes) for each job is known. What will be the order in which the jobs should be processed in order to minimize the total elapsed time?

Job	Time for turning (in minutes)	Time for threading (in minutes)
1	8	6
2	11	9
3	13	10
4	9	8
5	6	8

(a) 5 - 3 - 2 - 4 - 1
(b) 5 - 2 - 3 - 4 - 1
(c) 5 - 2 - 3 - 1 - 4
(d) 4 - 5 - 1 - 2 - 3

294. (a)

According to Johnson's rule the sequence should be
5 - 3 - 2 - 4 - 1

Job	For turning	For threading
5	0 – 6	6 – 14
3	6 – 19	19 – 29
2	19 – 30	30 – 39
4	30 – 39	39 – 47
1	39 – 47	47 – 53

Q.295 The minimum initial transportation cost for the given transportation problem is ₹_____ using the Vogel's approximation method. The cells contain the transportation cost in rupees.

	W_1	W_2	W_3	Available
F_1	7	6	4	50
F_2	8	5	6	60
F_3	6	8	9	40
Required	60	60	30	150(Total)

(a) ₹800
(b) ₹840
(c) ₹760
(d) None of these

295. (a)

	W_1	W_2	W_3	
F_1	[7] 20	[6]	[4] 30	2 2 1
F_2	[8]	[5] 60	[6]	1 1 [3]
F_3	[6] 40	[8]	[9]	[2]
	1 1 1	1 1 1	2 [2]	

$$\text{Transportation cost} = 20 \times 7 + 4 \times 30 + 5 \times 60 + 6 \times 40 = ₹800$$

Q.296 Consider the following statements about pressure prism:

1. Its volume is equal to the resultant hydrostatic force.
2. Line of action of resultant force passes through the centroid of homogeneous prism.

Which of the above statements is/are wrong?

(a) 1 only
(b) 1 and 2 only
(c) 2 only
(d) none of these

296. (d)

The volume of pressure prism or pressure diagram is the total hydrostatic force on the body and the centre of gravity of pressure diagram is center of pressure.

Q.297 A turbine is to be operated under a head of 20 m at 200 rpm. If the discharge is 8 m^3/s and turbine efficiency is 90%. The power output of the turbine and the type of turbine is
(Take $g = 10\ m/s^2$)

(a) 3200 kW, Pelton
(b) 1440 kW, Pelton
(c) 1440 kW, Kaplan
(d) 1440 kW, Francis

297. (d)

As per given data: $H = 20$ m, $N = 200$ rpm, $Q = 8\ m^3/s$, $\eta_o = 0.9$, $g = 10\ m/s^2$

$$\text{Efficiency of the turbine, } \eta_o = \frac{P}{\rho g Q H}$$

$$P = \eta_o \rho g Q H$$

$$= 0.9 \times 1000 \times 10 \times 8 \times 20 = 1440 \text{ kW}$$

$$N_S = \frac{N\sqrt{P}}{H^{5/4}} = \frac{200\sqrt{1440}}{(20)^{1.25}} = \frac{200 \times 12\sqrt{10}}{20 \times (20)^{0.25}}$$

$$= \frac{120(10)^{1/4}}{(2)^{1/4}} = (120) \times (5)^{1/4} \quad [\because \sqrt{5} = 2.236]$$

$$= (120) \times (2.236)^{1/2}$$

$$= (120) \times 1.495 \left\{\because \sqrt{2.25} = 1.5\right\}$$

$$= 179.4$$

As specific speed range for Francis turbine is 60–300.

Q.298 The air speed probe is mounted under the wing of an airplane measures the air speed at that location. The approach of this velocity measurement is considered as,
(a) Lagrangian approach
(b) Eulerian approach
(c) Pascal's approach
(d) Bernoulli's approach

298. (b)
- **Lagrangian approach:** Follow arbitrary amount of fluid particle to simulate the whole flow.
- **Eulerian approach:** Observe arbitrary amount of fluid particle to simulate the whole flow.

Q.299 Consider the following statements:
1. Vorticity is a measure of rotation of a fluid particle.
2. Vorticity vector is defined by curl of velocity vector.
3. Volumetric strain rate may be negative for fluid.

Which of the above statements are correct?
(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1, 2 and 3

299. (d)

Angular velocity, $\vec{\omega} = \frac{1}{2}\vec{\Omega}$ [where, $\vec{\Omega}$ is vorticity vector]

Vorticity vector, $\vec{\Omega} = \text{curl}(\vec{V})$, [where, $\vec{V}$ = velocity vector]

Volumetric strain rate is negative when fluid is compressed (generally for gases).

Q.300 For a given velocity profile $\frac{u}{U_\infty} = \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$, the shear stress at wall in any arbitrary location is given by $\tau_o = A\left(\frac{\mu U_\infty}{\delta}\right)$. The value of constant 'A' is
(a) 1.55 (b) 1.57
(c) 1.56 (d) 1.5

300. (d)

As per given data: $\frac{u}{U_\infty} = \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$

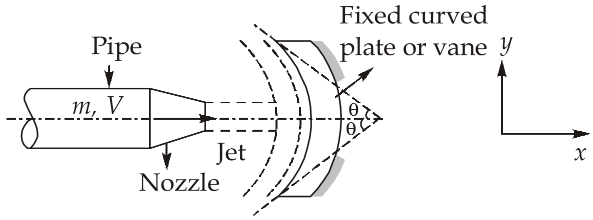
$$\tau_0 = A\left(\frac{\mu U_\infty}{\delta}\right) \quad ...(i)$$

$$\left(\frac{du}{dy}\right) = \left(\frac{3}{2\delta} - \frac{3}{2}\frac{y^2}{\delta^3}\right) \times U_\infty$$

$$\therefore \quad \tau_0 = \mu\left(\frac{du}{dy}\right)_{y=0} = \frac{3}{2}\left(\frac{\mu U_\infty}{\delta}\right) \quad ...(ii)$$

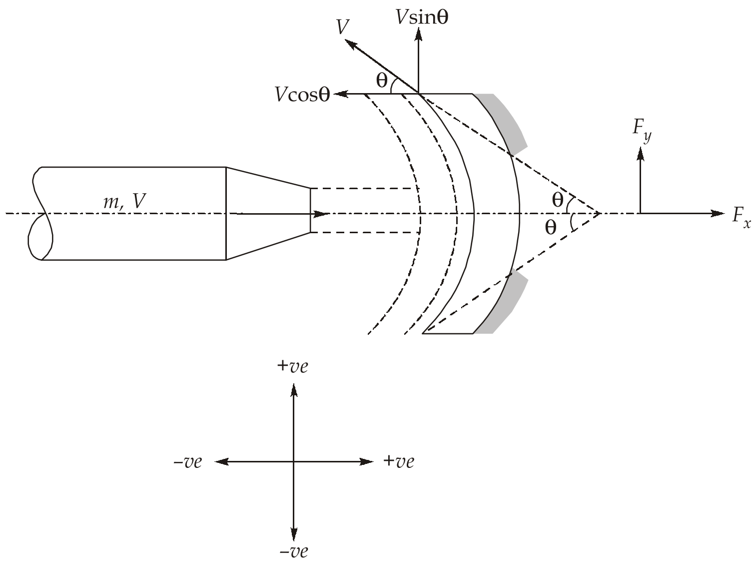
Comparing equation (ii) with equation (i),
i.e. A = 1.5

Q.301 If jet strikes symmetrically at the centre of a curved smooth plate then the force exerted by the jet along x and y direction respectively is.



(a) mV(1 + sinθ), mV(1 + cos θ)
(b) mV(1 + sin2θ), mV(1 + cos 2θ)
(c) mV(1 + cosθ), 0
(d) mV(1 + cos2θ), 0

301. (c)



Sign convection for velocity and force

m = Mass flow rate of water striking on the curved plate

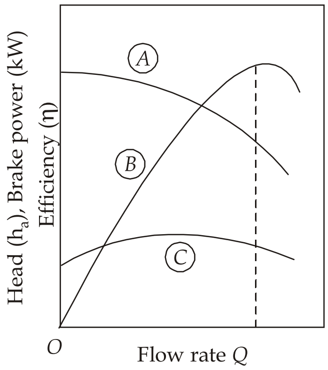
F_x = Rate of change of momentum in the direction of force
= Initial momentum – Final momentum
$= mV - (-m_1 V\cos\theta - m_2 V\cos\theta)$
$= mV + (m_1 + m_2)\, V\cos\theta$
$= mV + mV\cos\theta$ $(\because m = m_1 + m_2)$ from mass conservation

$F_x = mV(1 + \cos\theta)$

Due to symmetry of the plate the force exerted by the jet along y-direction or perpendicular to the direction of jet will be zero.

Q.302 Match **List-I** (characteristics curve) a typical performance characteristics curve for a centrifugal pump of a given size and operating at a constant impeller speed with **List-II** (variable) and select the correct answer using the codes given below in the lists:

List-I



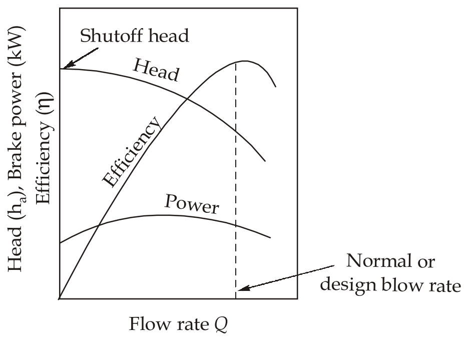
List-II

1. Efficiency
2. Head
3. Power

Codes:

	A	B	C
(a)	1	3	2
(b)	2	1	3
(c)	3	2	1
(d)	2	3	1

302. (b)



Q.303 Two geometrically similar pumps are running at 900 rpm speed (both). If one pump has impeller diameter of 0.25 m and discharge 25 l/s against 25 m head and the other pump gives half of this discharge rate, then the head and diameter of second pump is given by:

(a) 15.75 m and 0.15 m
(b) 15.75 m and 0.2 m
(c) 10.5 m and 0.25 m
(d) 10.5 m and 0.2 m

303. (b)

Model laws in pumps

- $$\left(\frac{\sqrt{H}}{DN}\right)_m = \left(\frac{\sqrt{H}}{DN}\right)_p$$

$$\Rightarrow \quad H_2 = H_1\left(\frac{D_2}{D_1}\right)^2 \qquad \text{(Given, } N_m = N_p\text{)}$$

- $$\frac{Q}{ND^3} = \text{Constant}$$

$$Q_2 = Q_1\left(\frac{D_2}{D_1}\right)^3$$

Given,
$$\frac{Q_2}{Q_1} = \frac{1}{2}$$

So,
$$\left(\frac{D_2}{D_1}\right)^3 = \frac{1}{2}$$

$$H_2 = 25\times\left(\frac{1}{2}\right)^{2/3} = \frac{25}{4^{1/3}} = \frac{25}{1.587}$$

$$H_2 = 15.749 \text{ m}$$

$$D_2 = D_1\left(\frac{1}{2}\right)^{1/3} = \frac{0.25}{1.26} = 0.198 \text{ m}$$

Q.304 Which of the following statements are INCORRECT with respect to impulse turbine?

1. Aerofoil type blades are used in impulse turbine.
2. Not all around or complete admission of steam takes place in impulse turbine.
3. Occupies more space for same power with respect to reaction turbine.
4. Lesser blade efficiency with respect to reaction turbine.

(a) 2 and 4 (b) 1 and 3
(c) 1 and 4 (d) 1, 2 and 4

304. (b)

Characteristics of impulse turbine:

- Constant blade channel area.
- Profile type blades.
- Not much power can be developed.
- Occupies less space for same power.
- Blade manufacturing is not difficult with respect to reaction turbine and thus not costly.
- Velocity of steam is slightly higher.

Q.305 In case of an air-breathing aircraft which is flying at an altitude where the air density is half of the value at the ground level. The air fuel ratio at this altitude with reference to the ground level will be

(a) 2 (b) $\sqrt{2}$

(c) $\frac{1}{2}$ (d) $\frac{1}{\sqrt{2}}$

305. (c)

- An air breathing jet engine (or ducted jet engine) is a jet engine propelled by a jet of hot exhaust gases formed from air that is forced into the engine by several stages of centrifugal, axial or ram compression, which is then heated and expanded through a nozzle. They are typically gas turbine engines.
- As the volume inducted per unit time remains same (as it depends upon the area of inlet nozzle and velocity of aircraft). Hence density of the air is directly proportional to the mass of the air.
- Assuming the volume flow rate of the fuel constant the air-fuel ratio at the altitude will be half of that of at ground level.

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

$$\rho = \frac{1}{2}\rho_o$$

So,
$$m = \frac{m_o}{2}$$

Q.306 For the flow represented by $V = -y^2\vec{i} - 6x\vec{j}$, the equation of streamline passing through (1, 1) is:

(a) $9x^2 - y^3 = 8$ (b) $9y^2 - x^3 = 8$

(c) $8x^2 - y^2 = 7$ (d) $11x^2 - 3y^3 = 8$

306. (a)

Equation of streamline in 2D flow:

$$\frac{dx}{u} = \frac{dy}{v}$$

$$-\frac{dx}{y^2} = -\frac{dy}{6x} \rightarrow \text{Differential equation of streamline}$$

$$\int 6x\,dx = \int y^2 dy + c \;[\text{c is constant of integration}]$$

$$3x^2 = \frac{y^3}{3} + c$$

for (1, 1),
$$3 = \frac{1}{3} + c$$

$\Rightarrow$
$$c = 3 - \frac{1}{3} = \frac{8}{3}$$

$$3x^2 = \frac{y^3}{3} + \frac{8}{3}$$

$$9x^2 - y^3 = 8$$

Q.307 Ball made of a metal (specific gravity 8) is floating on mercury of specific gravity 13.6. What fraction of the volume of ball is visible?

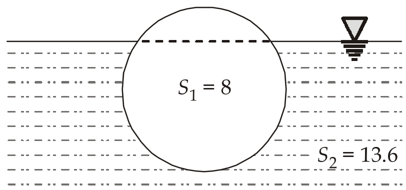
(a) 0.41 (b) 0.59
(c) 0.70 (d) 0.30

307. (a)

Let the volume of ball is V.

$$\text{Weight of ball} = 1000 \times 8 \times 9.81 \times V$$

Let volume V' is submerged



$$\text{Now buoyancy force } (F_B) = \text{weight}$$

$$1000 \times 13.6 \times 9.81 \times V' = 1000 \times 8 \times 9.81 \times V$$

$$\frac{V'}{V} = \frac{8}{13.6}$$

So $$\text{fraction visible} = \left(1 - \frac{V'}{V}\right) = \frac{5.6}{13.6} = 0.41$$

Q.308 A PERT network having probability of completion of project as 84.13% for a project duration of 26 days. If the standard deviation of activities along the critical path is $\frac{1}{3}, \frac{5}{3}, 1, 0$ and $\frac{1}{3}$. What will be the project duration for 50% probability of project completion?

(a) 24 days (b) 22 days
(c) 22.67 days (d) 24.17 days

308. (a)

Let the project duration for 50% probability of a project completion be T_s.

Given: Project duration for 84.13% probability of project completion, T = 26 days

We know that,

Variance = Sum of variances along critical path of network diagram along critical path

$$\sigma^2 = V = \left(\frac{1}{3}\right)^2 + \left(\frac{5}{3}\right)^2 + 1^2 + 0^2 + \left(\frac{1}{3}\right)^2$$

$$(\sigma)_{\text{Critical path}} = \sqrt{\frac{1 + 25 + 9 + 1}{9}}$$

$$(\sigma)_{\text{Critical path}} = 2$$

(z = 1 for 84.13% probability of project completion)

$$Z = \frac{T - T_s}{\sigma}$$

$$1 = \frac{26 - T_s}{2}$$

$$T_s = 24 \text{ days}$$

Project duration for 50% probability of project completion,

$$T_s = 24 \text{ days}$$

Q.309 The sale of refrigerator in May turns out to be 75 units whereas demand forecast was only 70 units. Next month demand forecast using exponential smoothing method is 72 units and actual demand turns out to be 82 units. What will be the forecast for the month of July using exponential smoothing method?

(a) 78 units
(b) 77 units
(c) 76 units
(d) 75 units

309. (c)

F_{May} = 70 units; D_{May} = 75 units; F_{June} = 72 units, D_{June} = 82 units

We know that,

$$F_{\text{June}} = F_{\text{May}} + \alpha(D_{\text{May}} - F_{\text{May}})$$

$$\Rightarrow \quad 72 = 70 + \alpha(75 - 70)$$

$$\Rightarrow \quad 2 = 5(\alpha)$$

Exponential smoothing constant, $\alpha = 0.4$

$$F_{\text{July}} = F_{\text{June}} + \alpha(D_{\text{June}} - F_{\text{June}})$$

$$= 72 + 0.4(82 - 72)$$

$$= 72 + 0.4 \times 10$$

Forecast for July, F_{July} = 76 units

Q.310 The work station time in a line balancing problem are 10 days, 12 days, 9 days, 13 days and 11 days. The cycle time is 15 days. Which of the following are correct regarding above data?

1. The value of smoothness index is $\sqrt{90}$.
2. The value of smoothness index is $\sqrt{30}$.
3. The balance delay is 15.38%.
4. The balance delay is 26.67%.

(a) 1 and 3
(b) 1 and 4
(c) 2 and 3
(d) 2 and 4

310. (d)

$$\text{Smoothness index} = \sqrt{\sum_{i=1}^{n}(\text{Maximum station time} - \text{Station time})^2}$$

$$= \sqrt{(13-10)^2 + (13-12)^2 + (13-9)^2 + (13-13)^2 + (13-11)^2}$$

$$= \sqrt{9+1+16+0+4} = \sqrt{30}$$

$$\text{Balance delay} = \left[\frac{n \times T_c - TWC}{n \times T_c}\right] \times 100\%$$

$$= \left[\frac{5\times 15 - (10+12+9+13+11)}{5 \times 15}\right] \times 100\% = \frac{20 \times 100}{75}\%$$

$$\text{Balance delay} = 26.67\%$$

Q.311 In a production system, average weekly demand of a product is 600 units and weekly standard deviation is 75 units. The lead time for a service level of 95.5% is 3 weeks. What will be the safety stock required for 95.5% service level? (Take, Z = 1.732 for a service level of 95.5%)

(a) 130 units
(b) 390 units
(c) 225 units
(d) 178 units

311. (c)

Given: Demand, D = 600 units; Standard deviation, σ = 75 units/week

Standard deviation corresponding to lead time,

$$\sigma' = \sqrt{\sigma^2 + \sigma^2 + \sigma^2}$$

$$\sigma' = (\sqrt{3})\sigma = (\sqrt{3}) \times 75 \text{ units}$$

$$\text{Safety stock, (S.S.)} = Z \times \sigma'$$

$$= 1.732 \times (\sqrt{3})\sigma = 1.732 \times \sqrt{3} \times 75$$

$$\text{Safety stock} = 3 \times 75 = 225 \text{ units}$$

Q.312 The *ABC* company requires 4000 units of particular item per month, average demand is 120 units per day. The production process is capable of producing 200 units per day. Each item produced in the plant costs Rs. 100. The set up cost per order is Rs. 1000. The inventory carrying cost per annum is 15% of the average inventory cost. What is the optimum quantity to be produced in each production run?

(a) 3100 units
(b) 1600 units
(c) 4000 units
(d) 2065 units

312. (c)

Given:

Annual demand, D = 4000 × 12 units

Daily consumption rate, d = 120 units/day

Rate of replenishment, p = 200 units/day

Set up cost, C_s = Rs. 1000

Unit cost of item, C = Rs. 100

Holding cost per item, C_h = 15% of 100 = Rs. 15/unit/year

$$EOQ = \sqrt{\frac{2DC_s}{C_h}\times\left(\frac{p}{p-d}\right)}$$

$$= \sqrt{\frac{2\times4000\times12\times1000\times200}{15\times(200-120)}}$$

$$= \sqrt{\frac{2\times4000\times12\times1000\times200}{15\times80}}$$

$$= \sqrt{2\times4000\times10\times200}$$

Optimum quantity to be produced in each production run,

EOQ = 4000 units

Q.313 For a production system, if variable cost is changed in such a manner that increase in break even point quantity is 8% and other factors remains same as earlier, then what will be the new variable cost per unit? If selling price = Rs. 400/unit, Fixed cost = Rs. 50000, Initial variable cost = Rs. 100/unit.

(a) Rs. 132
(b) Rs. 116
(c) Rs. 110
(d) Rs. 122

313. (d)

We know that,

$$\text{Breakeven point, }(\text{BEP})_1 = \frac{F}{(s-v_1)}$$

Now,

$$(\text{BEP})_2 = \frac{F}{(s-v_2)}$$

$$(1.08)(\text{BEP})_1 = \left(\frac{F}{s-v_2}\right)$$

$$\Rightarrow \quad 1.08\left(\frac{F}{s-v_1}\right) = \left(\frac{F}{s-v_2}\right)$$

$$1.08s - 1.08v_2 = s - v_1$$

$$(0.08 \times 400) = 1.08v_2 - (100)$$

$$(1.08)v_2 = 132$$

$$v_2 = \frac{132}{1.08} = \text{Rs. } 122.22$$

Q.314 A particular item has a demand of 5000 units/year. The cost of one procurement is Rs. 250 and the holding cost per unit is Rs. 2.5 per year. The replenishment is instantaneous and no shortage is allowed. The total cost per year is Rs. 17500, then what will be the cost of one unit?

(a) Rs. 3.0
(b) Rs. 3.2
(c) Rs. 3.4
(d) Rs. 3.5

314. (a)

Given,

Demand, D = 5000 units/year
Ordering cost, C_o = Rs. 250 per order
Holding cost, C_h = Rs. 2.5 per unit per year
Total cost, C_T = Rs. 17500
Unit cost = C

We know that,

$$\text{Total cost} = C \times D + \sqrt{2DC_0C_h}$$

$$17500 = C \times 5000 + \sqrt{2 \times 5000 \times 250 \times 2.5}$$

$$17500 = C \times 5000 + 2500$$

$$\frac{15000}{5000} = C$$

Unit cost, C = Rs. 3

Q.315 A project is consist of seven activities for which following data is given:

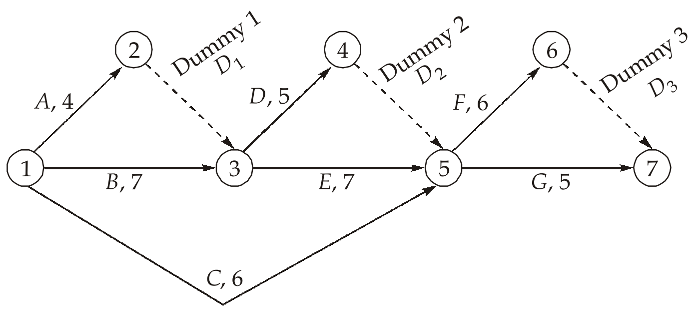
Activity	Preceding activities	Duration (days)
A	–	4
B	–	7
C	–	6
D	*A, B*	5
E	*A, B*	7
F	*C, D, E*	6
G	*C, D, E*	5

What will be the project completion time?

(a) 18 days
(b) 19 days
(c) 20 days
(d) 21 days

315. (c)

Network diagram:



Different paths are:

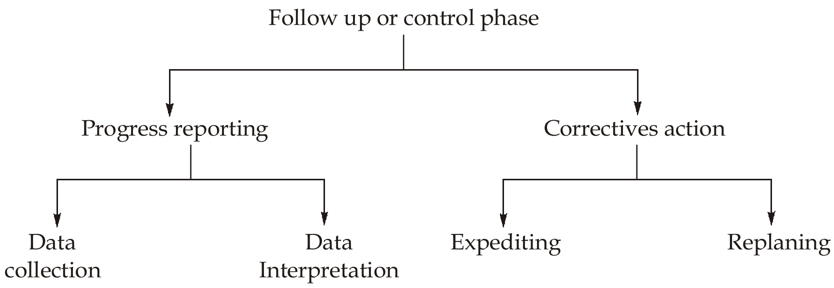
$$A - D_1 - D - D_2 - F - D_3 = 4 + 5 + 6 = 15 \text{ days}$$
$$A - D_1 - D - D_2 - G = 4 + 5 + 5 = 14 \text{ days}$$
$$A - D_1 - E - G = 4 + 7 + 5 = 16 \text{ days}$$
$$B - D - D_2 - F - D_3 = 7 + 5 + 6 = 18 \text{ days}$$
$$B - E - F - D_3 = 7 + 7 + 6 = 20 \text{ days}$$
$$B - E - G = 7 + 7 + 5 = 19 \text{ days}$$
$$C - F - D_3 = 6 + 6 = 12 \text{ days}$$
$$C - G = 6 + 5 = 11 \text{ days}$$

Q.316 Which of the following steps come under the follow up phase?

1. Data collection
2. Scheduling
3. Replanning
4. Expediting

(a) 1, 2 and 3
(b) 3 and 4
(c) 1, 3 and 4
(d) 1, 2, 3 and 4

316. (c)



Scheduling comes under active planning phase.

Direction (Q.317 to Q.320): The following questions consists of two statements, one labelled as **Statement (I)** and the other labelled as **Statement (II)**. You have to examine these two statements carefully and select your answers to these items using the codes given below:

Codes:

(a) Both Statement (I) and Statement (II) are true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are true but Statement (II) is not a correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

Q.317 Statement (I): Flow separation takes place only in case of external flow.
Statement (II): Adverse pressure gradient causes the flow to separate.

317. (d)

Flow separation can takes places in internal flow also, like in diverging section of a venturimeter.

Q.318 Statement (I): The losses in pump and turbine are of same kind, the losses in pumps are more due to eddies and turbulence.

Statement (II): The efficiency of turbine is generally less than that of pump.

318. (c)

- The efficiency of a pump is generally less than that of turbine.
- Other losses in pump are friction and eddy losses in diffusers

Q.319 Statement (I): Depth of center of pressure of any immersed surface is independent of the density of the liquid.

Statement (II): Center of area of the immersed surface is independent of the density of the liquid.

319. (b)

Q.320 Statement (I): The main objective of crashing a network is to minimize the cost of project and to make project duration optimum.

Statement (II): For achieving the minimum cost of project, we always crash an activity which is having least cost slope.

320. (c)

The main objective of crashing a network is to determine optimum project duration corresponding to minimum cost of project.

For minimizing the total cost of project, we select the critical activity on the critical path having minimum cost slope.