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PTQ

Prelims Through Questions

for

ESE 2021

Mechanical Engineering

Day 5 of 11

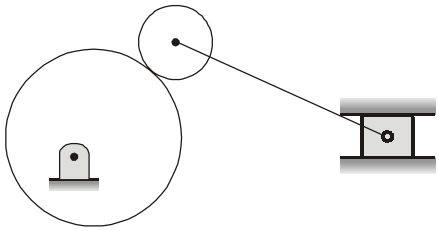
Q.181 - Q.230

(Out of 500 Questions)

Theory of Machines + Renewable Sources of Energy

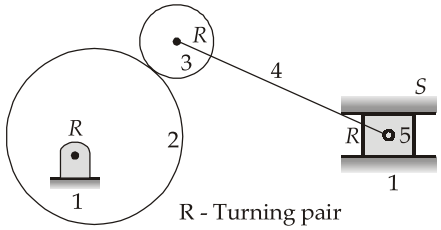
Theory of Machines + Renewable Sources of Energy

Q.181 What will be the degree of freedom of given kinematic chain?



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

181. (b)

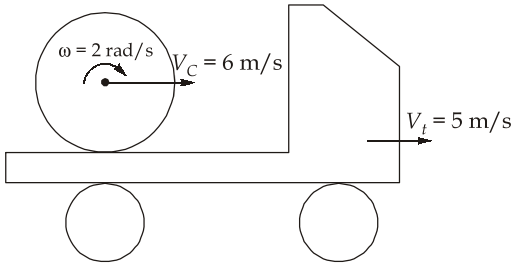


R - Turning pair
S - Sliding pair

Number of links, $n = 5$
Number of lower pairs, $j = 4$
Number of higher pairs, $h = 1$
Number of redundant degree of freedom, $F_r = 1$
(As the link 3 can be rotated without causing any change to rest of the mechanism)

$$F = 3(n-1) - 2j - h - F_r$$
$$= 3(5-1) - 2 \times 4 - 1 - 1 = 2$$

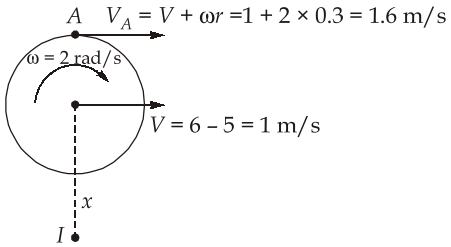
Q.182 A cylinder of radius 30 cm is rolling on the back of a truck which is moving at 5 m/s. The velocity of center of cylinder from ground is 6 m/s in the same direction as truck is moving. If the cylinder is rotating at 2 rad/s in clockwise direction when viewed from the right of the truck, the location of instantaneous center of rotation of cylinder and truck from center of cylinder will be at distance of



(a) 300 cm
(b) 550 cm
(c) 50 cm
(d) None of these

182. (c)

If we observe cylinder from the truck we will get following velocity of different point.



Let I be the instantaneous center of rotation which is at x distance from center then

$$\frac{V}{x} = \frac{V_A}{x+0.3}$$

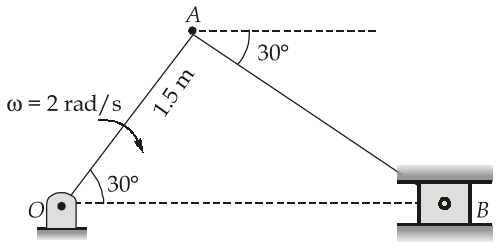
$$\Rightarrow \quad \frac{1}{x} = \frac{1.6}{x+0.3}$$

$$x + 0.3 = 1.6x$$

$$\Rightarrow \quad 0.3 = 0.6x$$

$$\Rightarrow \quad x = 0.5 \text{ m} = 50 \text{ cm}$$

Q.183 In a slider crank mechanism the crank is rotating at 2 rad/s in the direction shown below. What will be the velocity of slider?



(a) $\frac{3\sqrt{3}}{2}$ m/s

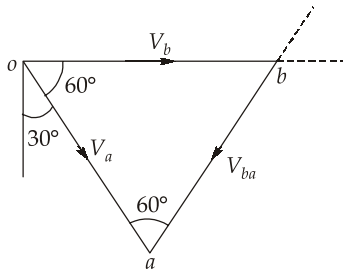
(b) $\frac{3}{2}$ m/s

(c) 3 m/s

(d) None of these

183. (c)

Drawing velocity diagram of given mechanism.

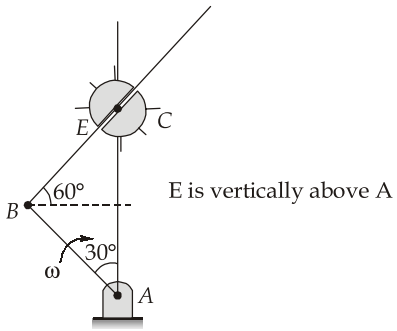


It forms an equilateral triangle

So, $V_b = V_a = \omega(OA)$

$= 2 \times 1.5 = 3$ m/s

Q.184 In the figure shown, crank AB is 10 cm long and is rotating at 10 rad/s. C is vertically above A. C is a swivel trunnion through which BE slides. What will be the angular velocity of swivel trunnion for the configuration shown?



(a) 10 rad/s

(b) 5 rad/s

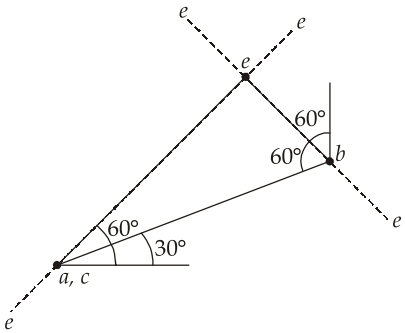
(c) $\frac{10}{\sqrt{3}}$ rad/s

(d) $5\sqrt{3}$ rad/s

184. (b)

$$V_B = \omega \times AB = 10 \times 10 = 100 \text{ cm/s}$$

Drawing velocity diagram of the mechanism,



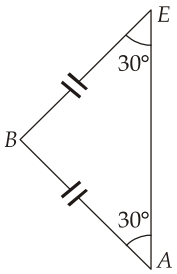
We know, $ab = V_B = 100$ cm/s

As, $be = ab\cos 60°$

$\Rightarrow$ $\omega_{be} \times BE = 100 \times \frac{1}{2}$

$$\omega_{be} = \frac{50}{BE}$$

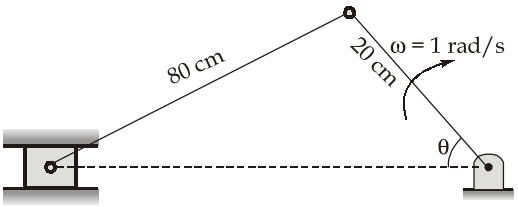
From the configuration diagram we can observe, $AB = BE$



So, $\omega_{be} = \frac{50}{10} = 5$ rad/s

Angular velocity of swivel trunnion = ω_{be} = 5 rad/s

Q.185 For the slider crank mechanism, what will be the velocity of slider at θ = 30°?



(a) 0.14 m/s
(b) 0.20 m/s
(c) 0.11 m/s
(d) 0.23 m/s

185. (a)

$$\text{Velocity of slider, } V = r\omega\left(\sin\theta + \frac{\sin 2\theta}{2\sqrt{n^2 - \sin^2\theta}}\right)$$

Given: r = 0.20 m, l = 0.80 m, ω = 1 rad/s, θ = 30°, n = 4

$$V = 0.2 \times 1\left(\sin 30° + \frac{\sin 60°}{2 \times \sqrt{4^2 - \frac{1}{4}}}\right)$$

$$\simeq 0.1218 \text{ m/s}$$

Note: At θ = 30°, exact velocity is 0.1218 m/s. As clockwise direction is given in question, (θ) will always increase, so according to options, options (c) i.e. 0.11 m/s cannot be possible because 0.11 m/s is at lower value of θ i.e. 28°. [Cannot be lower than 30° as clockwise direction is given]. So, best possible answer will be next higher value than 0.1218 m/s i.e. option (a).

Q.186 Consider the following statements regarding punching press:

1. During the actual punching operation, the speed of flywheel decreases.
2. Flywheel is used in punching press to compensate the fluctuation in speed of motor.

Select the correct statement(s) using the code given below:

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

186. (a)

The energy or power supplied by motor is constant hence statement 2 is wrong. The energy supplied by motor in whole cycle is absorbed by the flywheel. During the actual punching press do work on the sheet and during this period the speed of flywheel decreases.

Q.187 Consider the statements regarding the cams and followers:

1. The knife edge follower is simple from the analysis point of view.
2. The chances of jamming in the bearings of flat face follower are less as compared to knife edge and roller followers.
3. Flat-face follower is used in automobiles while roller follower is used in larger stationary gas or oil engines.

Which of the above statements is(are) correct?

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

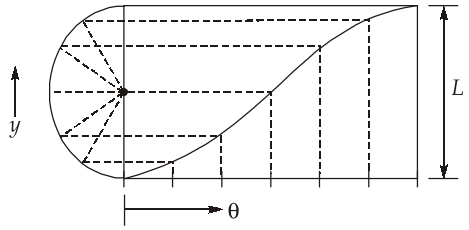
187. (d)

All the three statements given regarding followers are correct. The side thrust exerted by flat face follower is less than that of knife-edge and roller follower, hence chances of jamming is less.

In a flat face follower, there is no component of normal force that can apply side thrust hence side thrust is less.

The flat face follower is used in automobiles where space is limited. The use of roller followers is restricted by the minimum size of the pin to be used to connect the roller with the follower. Roller followers are common in larger stationary gas or oil engines.

Q.188 In the given diagram, a semicircle of diameter L is drawn and divided into the circular arcs of equal length. Which type of follower motion is represented by this displacement diagram?



(a) Uniform motion
(b) Simple harmonic motion
(c) Uniform acceleration motion
(d) Cycloidal motion

188. (b)

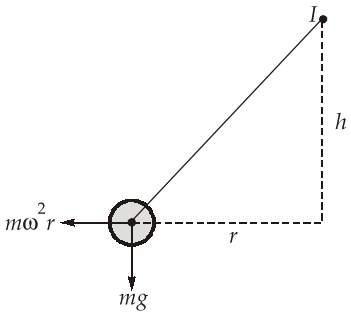
The SHM is represented by the projection of a particle motion on the diameter of circle on which the particle is moving with constant velocity.

Q.189 For a Watt governor, the height of the governor is 50 cm, then what will be the equilibrium rotational speed?

(a) 42 rpm
(b) 40 rpm
(c) 44 rpm
(d) 30 rpm

189. (a)

For Watt governor, taking moment about I



$$(m\omega^2 r)h = mgr$$

$$\Rightarrow \quad \omega^2 = \frac{9.81}{0.5}$$

$$\Rightarrow \quad \omega^2 = 19.62$$

$$\Rightarrow \quad \omega = 4.429$$

$$\Rightarrow \quad \frac{2\pi N}{60} = 4.429$$

$$\Rightarrow \quad N = \frac{4.429 \times 60}{2 \times \frac{22}{7}} = 42.2768 \text{ rpm}$$

Q.190 Consider the following terms regarding terminology of gears.

1. The radial distance between the pitch circle and the bottom land of the gear is called the dedendum.
2. The amount by which the dedendum of a gear exceeds the addendum of the mating gear is known as the clearance.

Select the correct statements using the code of given below:

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

190. (c)

Q.191 Consider the following statements regarding involute gears:

1. The locus of point of contact is straight line.
2. The path of approach is more than the path of recess.
3. Contact ratio can be less than 1.

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

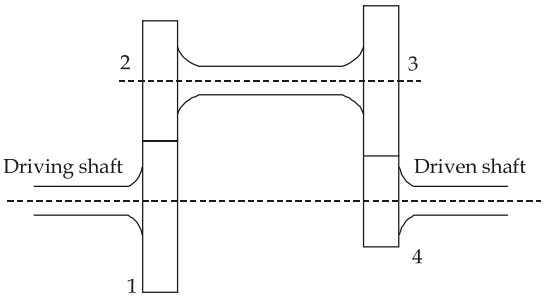
(a) 1 only (b) 2 only

(c) 3 only (d) 2 and 3

191. (d)

The path of approach can be more or less than the path of recess depending upon the various dimensions. Contact ratio should be at least 1 otherwise contact between the gears will break.

Q.192 Gear 1 and 4 have module 2 mm and 2.5 mm respectively of reverted gear train which is shown in figure. If the number of teeth on gear 1, 2 and 3 are 40, 20 and 36 respectively then what will be the speed ratio of given gear train?



(a) 6 (b) $\frac{1}{6}$

(c) 3 (d) Data not sufficient

192. (b)

Center distance will be equal for gears 1 and 2 and gears 3 and 4 so

$$r_1 + r_2 = r_3 + r_4$$

$$\Rightarrow \quad \frac{m_1}{2}(T_1 + T_2) = \frac{m_4}{2}(T_3 + T_4)$$

(Module of gears 1 and 2 is equal and same is for gears 3 and 4).

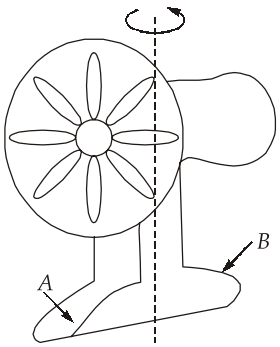
$$\Rightarrow \quad 2(40 + 20) = 2.5(36 + T_4)$$

$$\Rightarrow \quad T_4 = 12$$

$$\text{Speed ratio} = \frac{\text{Speed of driving shaft}}{\text{Speed of driven shaft}}$$

$$= \frac{N_1}{N_4} = \frac{T_2 \cdot T_4}{T_1 \cdot T_3} = \frac{20 \times 12}{40 \times 36} = \frac{1}{2} \times \frac{1}{3} = \frac{1}{6}$$

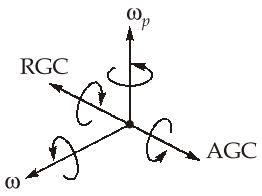
Q.193 Monu bought a chargeable table fan because of intermittent power supply. During testing the fan, he observed fan blade is rotating in clockwise direction when viewed from behind.



Due to gyroscopic couple, the fan may topple so Monu needs to press at A or B to balance the couple. If fan is rotating in anticlockwise direction when viewed from top, then where do Monu needs to press to balance gyroscopic couple?

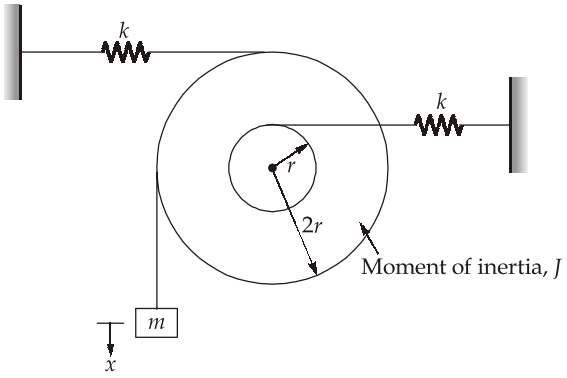
(a) A
(b) B
(c) Can't decide because of insufficient data
(d) At nowhere as there is no gyroscopic couple

193. (a)



Monu needs to press at A to balance RGC (Reactive gyroscopic couple).

Q.194 A hollow cylinder of mass M having inner and outer radius as r and $2r$ respectively is pin jointed. It is also attached to two springs as shown with a mass m attached to it. What will be the natural frequency of the system?



(a) $\sqrt{\dfrac{3kr^2}{J+4mr^2}}$

(b) $\sqrt{\dfrac{5kr^2}{J+4mr^2}}$

(c) $\sqrt{\dfrac{5kr^2}{J+2mr^2}}$

(d) $\sqrt{\dfrac{3kr^2}{J+Mr^2+2mr^2}}$

194. (b)

Applying energy method.

$$\frac{1}{2}k(2r\theta)^2+\frac{1}{2}k(r\theta)^2+\frac{1}{2}J\left(\dot{\theta}\right)^2+\frac{1}{2}m\left(2r\dot{\theta}\right)^2=0$$

$$\Rightarrow \quad \frac{5kr^2\theta^2}{2}+\frac{1}{2}\left(J+4mr^2\right)\dot{\theta}^2 = 0$$

Differentiating

$$\Rightarrow \quad 5kr^2\theta+\left(J+4mr^2\right)\ddot{\theta} = 0$$

$$\Rightarrow \quad \omega_n = \sqrt{\frac{5kr^2}{J+4mr^2}}$$

Q.195 For vibration isolation of a system working above twice the resonance frequency, we prefer

(a) underdamped system

(b) critically damped system

(c) overdamped system

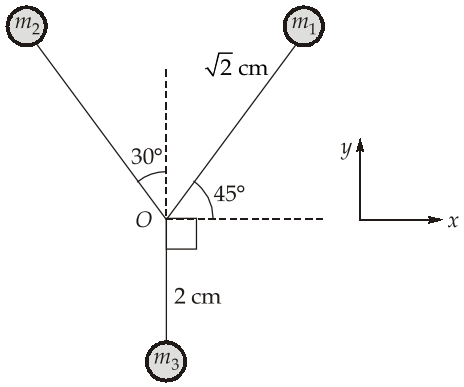
(d) will depend on other parameters

195. (a)

$$\text{Machine transmissibility, } \varepsilon = \frac{F_t}{F_o} = \sqrt{\frac{1+\left(\frac{2\xi\omega}{\omega_n}\right)^2}{\left[1-\left(\frac{\omega}{\omega_n}\right)^2\right]^2+\left(\frac{2\xi\omega}{\omega_n}\right)^2}}$$

for $\omega > \sqrt{2}\omega_n$, as $\xi \downarrow$ so underdamped system is desirable

Q.196 Three masses are arranged as shown and are rotating about 'O'. What will be the value of m_3 such that the arrangement is statically balanced? (Given m_1 = 2 kg and m_2 = 3 kg)



(a) 2.73 kg
(b) 1.58 kg
(c) 2.00 kg
(d) Data is insufficient

196. (a)

In x-direction,

$$m_1 r_1 \cos 45° = m_2 r_2 \sin 30°$$

$$2 \times \sqrt{2} \times \frac{1}{\sqrt{2}} = 3 \times r_2 \times \frac{1}{2}$$

$$\Rightarrow \quad r_2 = \frac{4}{3}\text{ cm}$$

In y-direction,

$$m_3 r_3 = m_2 r_2 \cos 30° + m_1 r_1 \sin 45°$$

$$m_3 \times 2 = 3 \times \frac{4}{3} \times \frac{\sqrt{3}}{2} + 2 \times \sqrt{2} \times \frac{1}{\sqrt{2}}$$

$$m_3 = \frac{2\sqrt{3}+2}{2} = \sqrt{3}+1 = 2.73205$$

Q.197 Select the correct statements related to Oldham's coupling:

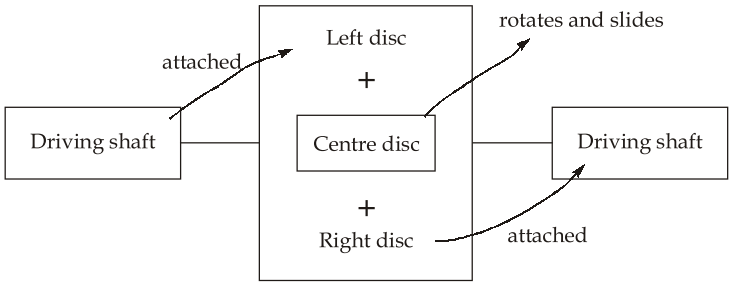
1. It is the inversion of single slider crank chain.
2. It is the inversion of double slider crank chain.
3. The intermediate link slides in the two slots, in two flanges while having the rotary motion.
4. It possess high moment of inertia accompanied by low torsional stiffness.

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

197. (b)

i. Oldham coupling is the inversion of double slider crank chain.
ii. It has low moment of inertia.
iii. It has high torsional stiffness.

iv.



Q.198 Consider the following statements about gear terminology and standards

1. The pitch circle is the circle centred on the gear axis and passing through the pitch point.
2. The diametral pitch is the number of teeth on the gear per unit of pitch circle diameter.
3. The circular pitch is the curvilinear distance measured on the base circle from a point on one tooth to the corresponding point on the next tooth.

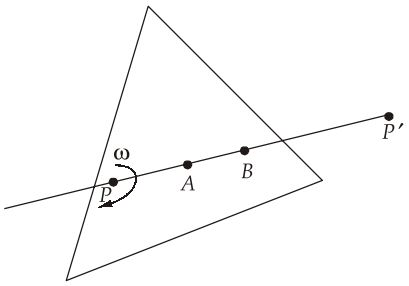
Choose the correct statements using the codes given below:

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

198. (c)

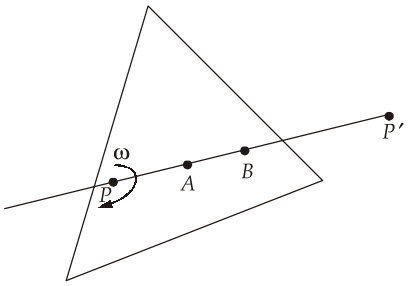
The circular pitch is the curvilinear distance measured on the pitch circle from a point on one teeth to the corresponding point on the next tooth.

Q.199 The rigid triangular plate shown in its plan view in the figure rotates in a plane parallel to the horizontal plane about P at a uniform angular velocity 5 rad/s. Two other points A and B are located on the line PP' at distances 45.7 cm and 58.9 cm from P respectively, then the velocity of point B with respect to point A is a given by:



(a) 66 m/s
(b) 0.66 m/s
(c) 2.945 m/s
(d) 2.285 m/s

199. (b)



Velocity of point B with respect to point 'A' = $\omega(PB - PA)$

$= 5 \times (58.9 - 45.7) \times 10^{-2} = 0.66$ m/s

Q.200 Which one of the following expression is correct for minimum number of teeth required on the pinion in order to avoid interference. (By assuming A_G addendum of gear, A_p addendum of pinion, T number of teeth on gear, t number of teeth on pinion)

(a) $\dfrac{2A_G}{\sqrt{\left(1+\left(\dfrac{t}{T}\right)\left(\dfrac{t}{T}+2\right)\sin^2\phi\right)-1}}$

(b) $\dfrac{2A_p}{\sqrt{1+\left(\dfrac{t}{T}\right)\left(\dfrac{t}{T}+2\right)\sin^2\phi-1}}$

(c) $\dfrac{2A_G \times \dfrac{t}{T}}{\sqrt{1+\left(\dfrac{t}{T}\right)\left(\dfrac{t}{T}+2\right)\sin^2\phi-1}}$

(d) $\dfrac{2A_p \times \dfrac{t}{T}}{\sqrt{1+\left(\dfrac{t}{T}\right)\left(\dfrac{t}{T}+2\right)\sin^2\phi-1}}$

200. (c)

The minimum number of teeth required on the gear in order to avoid interference

$$T_{\min} = \frac{2A_G}{\sqrt{1+\left(\frac{t}{T}\right)\left(\frac{t}{T}+2\right)\sin^2\phi}-1}$$

Now, $$t_{\min} = \frac{T_{\min}}{G}$$

and $$G = \frac{T}{t}$$

The minimum number of teeth required on the pinion in order to avoid interference

$$t_{\min} = \frac{2A_G\left(\frac{t}{T}\right)}{\sqrt{1+\left(\frac{t}{T}\right)\left(\frac{t}{T}+2\right)\sin^2\phi}-1}$$

Q.201 Choose the correct statement regarding damped vibration system.

(a) A system in which motion is maintained by the internal elastic forces

(b) A system in which the energy possessed by the system is gradually dissipated in overcoming internal and external resistances to the motion

(c) A system in which a periodic disturbing force is applied to the body and the vibration has the same frequency as that of the applied force.

(d) none of these

201. (b)

In damped vibration system, the energy possessed by the system is gradually dissipated in overcoming internal and external resistance to the motion, and the body finally comes to rest in its original equilibrium position.

Q.202 The moment of inertia of the disc is 1.5 kg-m^2 and it is spinning at 500 rpm. If the shaft precesses through one revolution in 5s, then the gyroscopic couple experienced by the shaft is (in kg-m^2/s^2):

(a) $\frac{10\pi^2}{3}$ (b) $\frac{10\pi^2}{6}$

(c) $\frac{20\pi^2}{6}$ (d) $\frac{20\pi^2}{2}$

202. (d)

As per given data, $I = 1.5\ \text{kg-m}^2$

The angular velocity of spin of the disc,

$$\omega = \frac{2\pi\times500}{60} = \frac{100\pi}{6}\ \text{rad/s}$$

The angular velocity of precession ,

$$\omega_p = \frac{2\pi}{5}\ \text{rad/s}$$

Gyroscopic couple, $T = I\omega\omega_p$

$$= 1.5\times\frac{100\pi}{6}\times\frac{2\pi}{5} = 10\pi^2 = \frac{20\pi^2}{2}\ \text{kg-m}^2/\text{s}^2$$

Q.203 For a vertical single cylinder gas engine, crank is 100 mm in length and mass of reciprocating parts is 20 kg. Force due to gas pressure is 3800 N, angle turned by crank from top dead centre is 60°, ratio of connecting rod length to crank radius is 5. What will be the angular speed of engine so that there is zero net force on piston?

[Take, g = 10 m/s^2 and cylinder is above the crank shaft]

(a) 67.80 rad/s (b) 60.30 rad/s

(c) 70.70 rad/s (d) 80.90 rad/s

203. (c)

$r = 100\ \text{mm} = 0.1\ \text{m}$, $m = 20\ \text{kg}$, $F_p = 3800\ \text{N}$, $\theta = 60°$, $n = 5$, $g = 10\ \text{m/s}^2$,

Force on the piston, $F = F_p + mg - F_I$

$$0 = 3800 + 20\times10 - mr\omega^2\left[\cos60° + \frac{\cos120°}{5}\right]$$

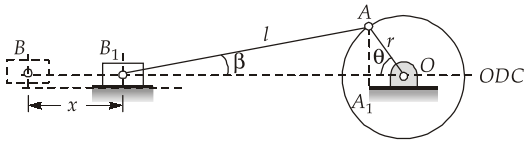
$$4000 = 20\times0.1\times\omega^2\left[0.5 - \frac{1}{10}\right]$$

$$\frac{2000}{0.4} = \omega^2$$

$$\omega^2 = 5000$$

$$\omega = 70.71\ \text{rad/s}$$

Q.204 Which one of the following is true regarding displacement of piston in single slider crank mechanism?



(a) $x = r\left[(1-\cos\theta)+\left(n-\sqrt{n^2-\sin^2\theta}\right)\right]$

(b) $x = r\left[(1-\sin\theta)+\left(n-\sqrt{n^2-\cos^2\theta}\right)\right]$

(c) $x = r\left[(1-\cos\theta)+\left(n-\sqrt{n^2-\cos^2\theta}\right)\right]$

(d) $x = r\left[(1-\sin\theta)+\left(n-\sqrt{n^2-\sin^2\theta}\right)\right]$

204. (a)

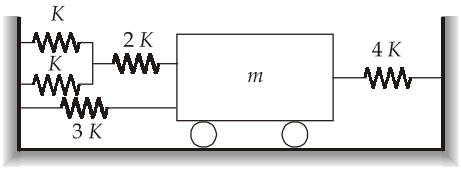
$$x = B_1B = BO - B_1O = BO - (B_1A_1 + A_1O)$$
$$= (l + r) - (l\cos\beta + r\cos\theta)$$
$$x = (nr + r) - (nr\cos\beta + r\cos\theta)$$
$$x = r[(n + 1) - (n\cos\beta + \cos\theta)]$$

$$\therefore \quad \cos\beta = \frac{1}{n}\sqrt{n^2 - \sin^2\theta}$$

$$x = r\left[(n+1) - \left(\sqrt{n^2 - \sin^2\theta} + \cos\theta\right)\right]$$

$$x = r\left[(1 - \cos\theta) + \left(n - \sqrt{n^2 - \sin^2\theta}\right)\right]$$

Q.205 The natural frequency of the system shown below is:

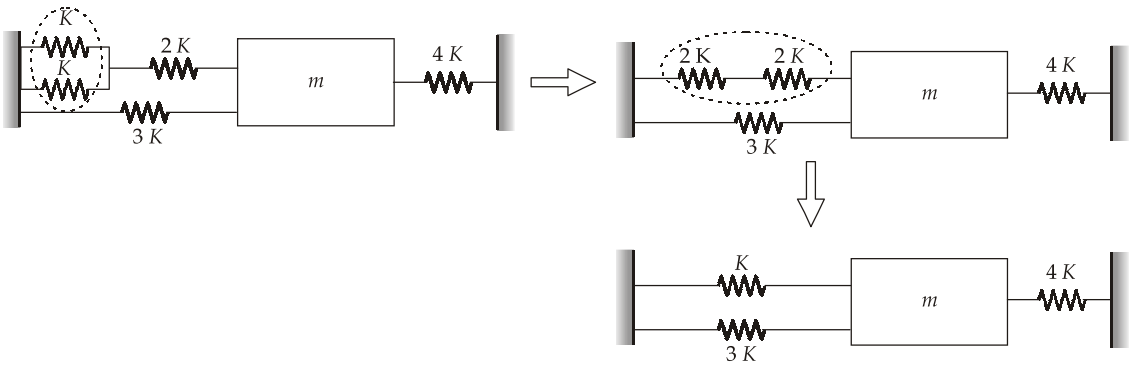


(a) $\sqrt{\frac{60\,K}{59\,m}}$ (b) $\sqrt{\frac{8K}{m}}$

(c) $\sqrt{\frac{37\,K}{5m}}$ (d) $\sqrt{\frac{K}{8m}}$

205. (b)

Computing equivalent stiffness of the system

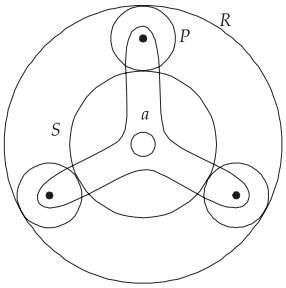


Now, all the three springs are in parallel, so $K_{eq} = K + 3K + 4K$

$$\Rightarrow \quad K_{eq} = 8K$$

So, $$\omega_n = \sqrt{\frac{K_{eq}}{m}} = \sqrt{\frac{8K}{m}}$$

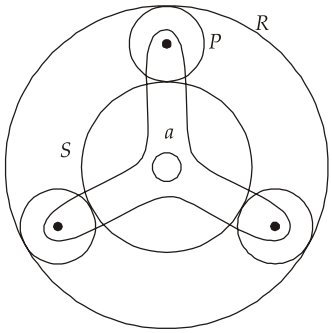
Q.206 In a simple epicyclic gear train as shown in the figure, the number of teeth on ring gear, R = 120, and number of teeth on sun gear, S = 80. The speed ratio of the sun gear S to planet gear P, when ring gear is fixed, is _____.



(a) $\frac{1}{2}$ (b) -2

(c) $\frac{-1}{2}$ (d) $\frac{-1}{4}$

206. (c)



$T_R = 120$; $T_S = 80$

If 'r' is the pitch circle radius of a gear,

$$r_s + 2r_p = r_R$$

$$\Rightarrow \quad \frac{mT_s}{2} + 2m\frac{T_p}{2} = m\frac{T_R}{2}$$

$$\Rightarrow \quad T_s + 2T_p = T_R$$

$$\Rightarrow \quad 80 + 2T_p = 120$$

$$\Rightarrow \quad 2T_p = 120 - 80$$

$$\Rightarrow \quad T_p = 20$$

Arm	$S(80)$	$P(20)$	$R(120)$
Fixed	$+1$	$-1\times\frac{T_s}{T_p}$ $= -1\times\frac{80}{20} = -4$	$-1\times\frac{T_s}{T_p}\times\frac{T_P}{T_R}$ $= -1\times\frac{80}{120} = -\frac{2}{3}$
$+y$	$+x$ $y+x$	$-4x$ $y-4x$	$-\frac{2}{3}x$ $y-\frac{2}{3}x$

Since, ring gear R is fixed,

$$y - \frac{2}{3}x = 0 \Rightarrow y = \frac{2}{3}x$$

From (i):

$$N_s = y + x = \frac{2}{3}x + x = \frac{5x}{3}$$

From (ii):

$$N_p = y - 4x = \frac{2}{3}x - 4x = \frac{-10x}{3}$$

Speed ratio, $$\frac{N_s}{N_p} = \frac{5x/3}{-10/3} = \frac{-1}{2}$$

Q.207 A simple single basin type tidal power plant has a basin area of 20 km^2. The tide has a range of 10 m. Specific gravity of sea water is 1.03. What is the energy potential available for tidal power plant?
[Take g = 10 m/s^2]
(a) 460.85 × 10^6 MJ (b) 230.42 × 10^6 MJ
(c) 20.6 × 10^6 MJ (d) 10.3 × 10^6 MJ

207. (d)
Given: ρ = 1.03 × 1000 = 1030 kg/m^3, A = 20 km^2 = 20 × 10^6 m^2, g = 10 m/s^2, R = 10 m

$$\text{Energy potential available, } E_f = \frac{1}{2}\rho A g R^2$$

$$= \frac{1}{2}\times 1030 \times 20 \times 10^6 \times 10 \times 10^2$$

$$= 1030 \times 10^{10} = 10.3 \times 10^{12} \text{ Joule}$$

$$E_f = 10.3 \times 10^6 \text{ MJ}$$

Q.208 Wind at 1 bar of atmospheric pressure and 27°C temperature has upstream wind velocity of 10 m/s. Area of wind turbine blades is 287 m^2. What is the maximum power that can be extracted by the wind turbine?
(a) 98.8 kW (b) 106.4 kW
(c) 165.6 kW (d) 88.6 kW

208. (a)
According to Betz's law, no turbine can capture more than 16/27 (59.3%) of the kinetic energy in wind. The factor 16/27 (0.593) is known as Betz's coefficient.

$$P_{max} = (0.593)\times\left(\frac{1}{2}\rho \times A \times V_u^3\right) = (0.593)\times\frac{1}{2}\times\left(\frac{P}{RT}\times A \times V_u^3\right)$$

$$= \left(\frac{0.593}{2}\right)\times\left[\frac{100\times 287\times 10^3}{0.287\times 300}\right] = (0.2965)\times\left(\frac{10^6}{3}\right)$$

$$= \left(\frac{296.5}{3}\text{ kW}\right)$$

$$P_{max} = 98.83 \text{ kW}$$

Q.209 Consider the following statements regarding Renewable-Energy.
1. The renewable energy systems include power from solar radiation (sunshine), wind, biomass (plant crops), rivers (hydropower), ocean waves, tides, geothermal heat and other such continuing resources.
2. The energy which obtained from naturally repetitive and persistent flows of energy occurring in the local environment.
3. It is obtained from static stores of energy that remain underground unless released by human interaction.

Which of the above statements is/are correct?

(a) 1 only (b) 1 and 2 only

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

209. (b)

Non-renewable energy is energy obtained from static stores of energy that remain underground unless released by human interaction. Statement 3 is the definition of non-renewable energy.

Q.210 Consider the following statement regarding the electromagnetic radiation emitted by the sun.

1. The radiation emitted by the sun covers a very large range of wavelengths, from radio waves through the infrared, visible and ultraviolet to X-rays and gamma rays.
2. About 99 % of the energy of solar radiation is contained in the wavelength band from 0.2 μm to 4 μm.
3. About 48 % of the solar radiation received at the earth's surface on clear days is visible radiation within the spectral range 0.38 to 0.78 μm.
4. About 45.6 % is infrared radiation in the spectral region 0.78 to 4 μm.

Which of the above statements is/are correct?

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

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

210. (b)

The electromagnetic radiation emitted by the sun covers a very large range of wavelengths, from radio waves through the infrared, visible and ultraviolet to X-rays and gamma rays. However, 99 per cent of the energy of solar radiation is contained in the wavelength band from 0.2 to 4 μm, comprising the near ultraviolet, visible and near infrared regions of the solar spectrum, with a maximum at about 0.48 μm. About 48 per cent of the solar radiation received at the earth's surface on clear days is visible radiation within the spectral range 0.38 to 0.78 μm, while 45.6 per cent is infrared radiation in the spectral region 0.78 to 4 μm.

Q.211 For AM 1.5 G (i.e. Air mass index 1.5 Global), what will be the value of zenith angle corresponding to the given air mass?

(a) 0° (b) 90°

(c) 60° (d) 48.2°

211. (d)

$$\text{Air mass} = 1.5$$

$$\text{Air mass} = \frac{1}{\cos\theta_z}$$

$$\cos\theta_z = \frac{1}{\text{air mass}} = \frac{1}{1.5} = \frac{2}{3}$$

$$\theta_z = \cos^{-1}\left(\frac{2}{3}\right) = 48.189^\circ \approx 48.2^\circ$$

Q.212 Consider the following statements regarding the Surface Recombination in solar cells.

1. Surface recombination is high in solar cells.
2. By limiting surface recombination, it leads to better and more robust solar cell designs.

Which of the above statements is/are correct?

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

212. (c)

- The high recombination rate in the vicinity of a surface depletes this region of minority carriers. A localized region of low carrier concentration causes carriers to flow into this region from the surrounding, higher concentration regions. Therefore, the surface recombination rate is limited by the rate at which minority carriers move towards the surface.
- The lifetime of the material is contingent upon the concentration of minority carriers. Limiting surface recombination can lessen the rate at which minority carriers are depleted. If the rate of minority carrier depletion can be limited, the lifetime of the material can be extended.

Q.213 The important parameters of a semiconductor material for solar cell operation is/are:

1. The band gap
2. The number of free carriers (electrons or holes) available for conduction.
3. The "generation" and recombination of free carriers (electrons or holes) in response to light shining on the material.

Which of the above statements is/are correct?

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

213. (d)

Q.214 Consider the following statements regarding principal disadvantages of Vertical Axis Wind Turbines (VAWTs).

1. Vertical axis machines may suffer from fatigue failures arising from the many natural resonances in the structure.
2. The rotational torque from the wind varies periodically within each cycle, and thus unwanted power periodicities appear at the output.
3. Guyed tower support is complex.
4. In vertical-axis machines gravity-induced stress/strain cycles are eliminated.

Which of the above statements is/are correct?

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

214. (d)

The principal disadvantages of VAWTs are:

1. Many vertical axis machines have suffered from fatigue failures arising from the many natural resonances in the structure.
2. The rotational torque from the wind varies periodically within each cycle, and thus unwanted power periodicities appear at the output.
3. Guyed tower support is complex, as a result the great majority of working machines are horizontal axis, not vertical.

A major advantage of vertical-axis machines is to eliminate gravity-induced stress/strain cycles (which occurs during every rotation in the blades of horizontal axis turbines), so vertical-axis blades may be very large. For small machines, gearing and generators may be directly coupled to the vertical main shaft at ground level. However, for larger vertical-axis machines, the high torque of the main shaft requires it to be short, so generators are not at ground level.

Q.215 Consider the following statements regarding advantages of fuel cell over IC engines:

1. Fuel cells are silent as there is no moving part and hence long lasting and highly reliable.
2. No undesirable products like SOx, NOx and particulate emissions are virtually zero.

Choose the correct statements as above mentioned

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

215. (c)

Fuel cell advantages over IC engine:

- Fuel cells are silent as there is no moving part and hence long lasting and highly reliable.
- No undesirable products like SOx, NOx and particulate emissions are virtually zero.
- Fuel cells are not subject to the Carnot efficiency limit. If there is no 'irreversibility' the efficiency could be 100%.

Q.216 For a solar cell if the ratio of I_{max} to I_{sc} is 0.5, maximum voltage that cell can give and open circuit voltage are 0.045 V/cm^2 and 0.6 V/cm^2 respectively, then the fill factor is

[Where, I_{max} = Maximum current and I_{sc} = Short circuit current]

(a) 0.0489 (b) 0.489
(c) 0.0375 (d) 0.375

216. (c)

Given:

$$\frac{\text{Maximum Current}}{\text{Short circuit current}} = \frac{I_{max}}{I_{sc}} = \frac{1}{2}$$

Maximum voltage that cell can give = V_{max} = 0.045 V/cm^2

Open circuit voltage = V_{oc} = 0.6 V/cm^2

Then, Fill factor, FF $= \dfrac{I_{max} \times V_{max}}{I_{sc} \times V_{oc}} = \dfrac{1}{2} \times \dfrac{0.045}{0.6} = 0.0375$

Q.217 The Solar radiation with wavelength ranging from 0.2 μm to 0.48 μm concentrated in:

(a) Ultraviolet and visible region
(b) Visible and Infrared region
(c) Ultraviolet and Infrared region
(d) All regions with equal distribution

217. (a)

0.2 μm to 0.38 μm, extraterrestrial radiation energy is contained in the ultraviolet region.

0.38 μm to 0.48 μm, extraterrestrial radiation energy is contained in the visible region.

Q.218 Which of the following statement is INCORRECT about wind energy?

(a) It is the kinetic energy associated with movement of large masses of air.
(b) The wind motions result from uneven heating of the atmosphere by the sun.
(c) Wind turbine operates with little noise produced by rotor blades.
(d) The amount of energy in wind varies with the cube of the wind speed.

218. (c)

$$P = \frac{1}{2}\rho A V^3$$

- Wind power plants have relatively little impact on the environment as compared to fossil fuel power plants.
- The air motion result from un-even heating of the atmosphere by the sun, creating temperature, density and pressure difference.
- Wind energy can be available continuously throughout 24-hour day for much longer periods, though it can vary a great extent including no wind periods.

Disadvantages:

- It is dispersed, erratic and location specific source.
- Noise generated by wind turbine is of more than 85 db, hence badly affect ecosystem.
- Main concerns for wind turbine have been the noise produced by the rotor blades, visual impacts, and deaths of birds and bats that fly into the rotors (avian/bat mortality).

Q.219 A horizontal axis wind turbine (HAWT) having rotor diameter of 80 m and 3 blades with tip speed ratio (λ_0) of 4. The rotational speed of the turbine for energy extraction is near to: (Take the free wind velocity is equal to 15 m/s)

(a) 19 rpm (b) 5 rpm
(c) 25 rpm (d) 15 rpm

219. (d)

Given:

Rotor diameter = 80 m

$\Rightarrow$ Radius, R = 40 m

Free wind speed, u_0 = 15 m/s

$$\text{Tip speed ratio, } \lambda_0 = \frac{R\omega}{u_0}$$

$$4 = \frac{40 \times \omega}{15}$$

$$\omega = 1.5 \text{ rad/s}$$

If N is rotor speed in rpm, $\omega = \frac{2\pi N}{60}$

$$1.5 = \frac{2 \times 22}{60 \times 7} \times N$$

$$N = \frac{15}{10} \times \frac{7 \times 60}{2 \times 22}$$

$$N = 14.32 \text{ rpm} \approx 15 \text{ rpm}$$

Q.220 The tidal power developed is directly proportional to:

1. Area of basin
2. Cube of the range
3. Density of water
4. Acceleration due to gravity

Select the correct answer using the codes given below:

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

220. (c)

Consider water trapped at high tide in a basin of area A. The potential energy in the mass of water stored in incremental head dh above the head h is:

$$dW = dm.g.h$$

But $$dm = \rho.A.dh$$

Thus, $$dW = \rho Agh\ dh$$

Total potential energy of water stored in the basin is:

$$W = \int_0^R \rho Agh\ dh$$

$$W = \frac{1}{2}\rho AgR^2 \text{ Joules}\ ]$$

(Hence, tidal power is proportional to square of the range)

Where, ρ = Density of water

g = Acceleration due to gravity

Q.221 Why do wind turbines using aerodynamic lift produce more energy for a given swept area than wind turbine using aerodynamic drag?

(a) The lifting force pushes the blade in the direction the wind is already blowing.
(b) The lifting force is roughly perpendicular to local flow field.
(c) Lift produces more torque.
(d) Drag services capture more energy because of greater friction on blade surfaces.

221. (c)

Lift force produces more torque in comparison to the drag force.

Q.222 The process in which waste wood is pulverized, dried and forced under pressure through an extrusion device is known as:

(a) Briquetting (b) Incineration
(c) Pelletization (d) Pyrolysis

222. (c)

All these terms are related to bio-mass conversion technologies:

- Pelletization reduces moisture to about 7 to 10 percent and increase the heat value of the biomass. It is used in steam power plants and gasification system.
- Briquetting is brought about by compression and squeezing out moisture and breaking down the elasticity of the wood and bark.

- Incineration means direct combustion of biomass for immediate useful heat.
- The basic thermochemical process to convert biomass into a more valuable and/or convenient product is known as pyrolysis.

Q.223 Consider the following statements related to fuel cells:

1. It is quiet in operation.
2. The efficiency of conversion is better and not limited by Carnot efficiency of thermal stage.
3. No cooling water is required.
4. Fuel cell plants are compact and required less space.

Select the correct answer using the codes given below:

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

223. (d)

- As the conversion of chemical energy of fuel to electrical energy occurs directly without intermediate thermal stage, the efficiency of conversion is better and not limited by carnot efficiency of thermal stage.
- Fuel cell plant can be installed near the point of use, thus transmission and distribution losses are avoided.
- Availability of choices from large number of possible fuels.

Direction (Q.224 to Q.230): 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.224 **Statement (I):** Collector efficiency factor is defined as the ratio of the actual useful heat collection rate to the useful heat collection rate which would occur if the collector absorber plate were at temperature equal to temperature of fluid flowing in tubes.

Statement (II): Its value ranges from 0.9 to 0.95.

224. (b)

Q.225 **Statement (I):** In gasification where there is a surplus of solid fuel (incomplete combustion) the products of combustion are combustible gases like carbon monoxide (CO), hydrogen (H_2) and traces of methane and useless products like tar and dust.

Statement (II): Biomass gasification means complete combustion of biomass resulting in production of combustible gases consisting of carbon monoxide (CO), hydrogen (H_2) and traces of methane (CH_4).

225. (c)

Biomass gasification means incomplete combustion of biomass resulting in production of combustible gases consisting of carbon monoxide (CO), hydrogen (H_2) and traces of methane (CH_4). This mixture is called producer gas.

Q.226 Statement (I): Aerobic digestion is a bacterial process occurring in the absence of oxygen.
Statement (II): The aerobic digestion occurs much faster than anaerobic digestion and the capital costs of aerobic digestion are lower.

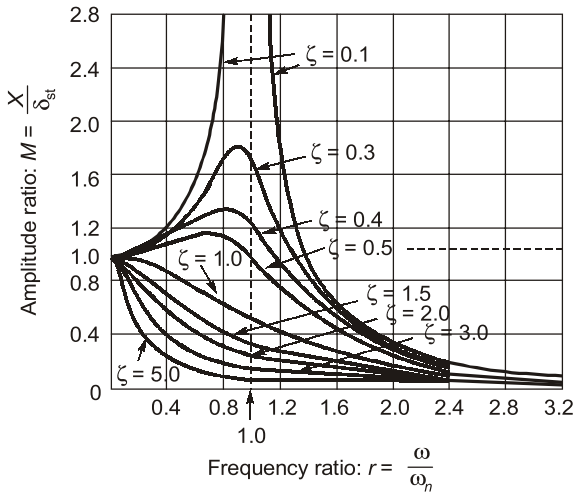
226. (d)

Aerobic digestion is a bacterial process occurring in the presence of oxygen. Therefore, Statement (I) is not correct.

Q.227 Statement (I): In forced damped vibrating system, the maximum amplitude of vibration occurs before the ratio (ω/ω_n) reaches unity.
Statement (II): In forced damped vibrating system, the phase angle remains constant irrespective of damping.

227. (c)

In forced damped vibrating system, the maximum amplitude of vibration occurs before the ratio (ω/ω_n) reaches unity.
Phase angle changes with damping.



$$\tan\phi = \frac{c\omega}{k - m\omega^2} = \frac{\frac{c}{m}\omega}{\frac{k}{m} - \omega^2} = \frac{2\xi\frac{\omega}{\omega_n}}{1 - \left(\frac{\omega}{\omega_n}\right)^2}$$

c = damping constant
k = stiffness, m = mass, ω = forced frequency

Q.228 **Statement (I):** A Hooke's joint is an example of plane mechanism.
Statement (II): In a plane mechanism, all the points of a mechanism move in parallel planes.

228. (d)
A Hooke's joint in an example of space mechanism as all points of its mechanism do not move in parallel planes.

Q.229 **Statement (I):** If the particle is moving along a circular path, the normal component of acceleration of the particle depends only upon its instantaneous velocity and radius of curvature of path.
Statement (II): If the displacement of the particle takes place along a straight-line then normal component of acceleration is zero.

229. (b)
(Tangential acceleration is zero for a particle moving along circular path)

and normal or radial acceleration, $a_n = a_r = v\frac{d\theta}{dt} = v\,\omega = \frac{v^2}{r} = r\omega^2$

Normal or radial component of acceleration = f (instantaneous velocity, radius of curvature)
In case of straight line motion

$$r \to \infty \;=\; a_n = a_r = 0$$

Q.230 **Statement (I):** The Porter governor only differs from the Watt governor because of the use of a heavily weighted sleeve.
Statement (II): The Porter governor is similar to the Proell governor but the only difference is that in the Porter governor the two masses are fixed on the upward extensions of the lower links.

230. (c)
The Proell governor is similar to the porter governor but the only difference is that in the Proell governor the two masses are fixed on the upward extensions of the lower links.