

Unit-I Worksheet

C1.1 The turbine rotor of a ship has a mass of 2000 kg and rotates at a speed of 3000 rpm clockwise when viewed from stern. The rotor has radius of gyration of 0.5 m. (a) Determine the gyroscopic couple and its effect when the ship steers to the right in a curve of 100 m radius at a speed of 16.1 knots (1 knot = 1855 m/h). (b) Calculate the torque and its effects when ship pitches simple harmonic motion, the bow falling with its maximum velocity, the period of pitching is 50 seconds and the total angular displacement between two extreme positions of pitching is 12 degrees. Find the maximum acceleration during the pitching motion.

C1.2 A rear engine automobile is travelling along a track of 100 m mean radius. Each of the four road wheels has a moment of inertia of 2.5 kg-m^2 and an effective diameter of 0.6 m. The rotating parts of the engine have a moment of inertia of 1.2 kg-m^2 . The engine axis is parallel to the rear axle and the crank shaft rotates in the same sense as the road wheels. The ratio of engine speed to back axle speed is 3:1. The automobile has a mass of 1600 kg and has its centre of gravity 0.5 m above road level. The width of the track of the vehicle is 1.5 m. Determine the limiting speed of the vehicle around the curve for all four wheels to maintain contact with the road surface. Assume that the road surface is not cambered and centre of gravity of the automobile lies centrally with respect to the four wheels.

MCQ's

1. A disc is spinning with an angular velocity of ω rad/sec about the axis of spin. The couple applied to the disc to cause precession will be

- a) $\frac{1}{2} I \omega^2$ b) $I \omega^2$ c) $\frac{1}{2} I \omega \omega_p$ d) $I \omega \omega_p$

Ans: d.

2. A disc spinning on its axis at 20 rad/sec will undergo precession when torque 100N-m is applied about an axis normal to it at an angular speed, if mass moment of inertia of disc is 1 kg-m^2

- a) 2 rad/sec b) 5 rad/sec c) 10 rad/sec d) 20 rad/sec

Ans: b

3. The air screw is rotating clockwise when looking from front view. If it makes a right turn, the gyroscopic couple will be

- a) Tend to depress the nose and raise the tail
b) Tend to raise the nose and depress the tail
c) Tilt the aero plane
d) None of the above

Ans: a

4. The engine rotates in clock wise direction when seen from tail end and it takes a left turn. The effect of gyroscopic couple will be

- a) To raise the nose and dip the tail
- b) To dip the nose and raise the tail
- c) To raise the nose and tail
- d) To dip the tail and nose

Ans:a

5. The rotor of the ship rotates in clock wise direction when viewed from stern and ship takes a left turn. Then effect of gyroscopic couple will be

- a) To raise the bow and stern
- b) to lower bow and stern
- c) to raise the bow and lower the stern
- d) to lower the bow and raise the stern

Ans: c

6. When the pitching of a ship is upward, the effect of gyroscopic couple on it will be

- a) To move the ship towards port board side
- b) To move the ship towards star-board side
- c) to raise the bow and lower the stern
- d) to lower the bow and raise the stern

Ans: b

7. In an automobile if a vehicle makes a left turn the gyroscopic torque will be

- a) Increases the forces on outer wheels
- b) Decreases the forces on outer wheels
- c) Does not affect the forces on outer wheels
- d) None of these

8. A motor car moving at a certain speed takes a left turn in a curved path. If the engine rotates in the same direction as that of wheels, the due to centrifugal forces,

- a) The reaction on inner wheels increases and outer wheels decreases
- b) The reaction on outer wheels increase and inner wheels decreases

- c) The reaction on front wheel increase and rear wheel decreases
- d) The reaction on rear wheel increase and front wheel decreases

Ans: b

9. The steering of a ship means

a) movement of a complete ship up and down in vertical plane about transverse axis

b) turning of a complete ship in a curve towards right or left, while it moves forward

c) rolling of a complete ship side-ways

d) none of the above

Ans. B

10. Two links OA and OB are connected by a pin joint at 'O'. The link OA turns with angular velocity ω_1 radians per second in the clockwise direction and the link OB turns with angular velocity ω_2 radians per second in the anticlockwise direction. If the radius of the pin at 'O' is 'r', then the rubbing velocity at the pin joint 'O' will be

- (a) $\omega_1\omega_2r$ (b) $(\omega_1-\omega_2)r$ (c) $(\omega_1 + \omega_2)r$ (d) $(\omega_1 - \omega_2) 2r$

Ans. (c)

11. If a number of forces act on a rigid body, each force may be replaced by an equal and parallel force acting through a fixed point, together with a couple. For the rigid body to be in equilibrium,

- (a) the resultant force at the fixed point must be zero
- (b) the resultant couple on the body must be zero
- (c) both resultant force and couple must be zero
- (d) none of the above need be zero

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Ans. (c)

13. The pitching of a ship in the ocean is an oscillatory periodic motion. A ship is pitching 6° above and 6° below with a period of 20s from its horizontal plane. Consider the following statements in this regard:

1. The motion has a frequency of oscillation (i.e. pitching) of 3 cycles/minute
2. The motion has an angular frequency of 3.14 rad/s.
3. The angular velocity of precession of ship's rotor is $\pi^2/300$ rad/s.
4. The amplitude of pitching is $\pi/30$ rad.

Which of these statements are correct?

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

Ans. (b)

14. The rotor of a ship rotates in clockwise direction when viewed from stern and the ship takes a right turn. The effect of gyroscopic couple acting on it will be to raise the stern and lower the bow.

A. Agree

B Disagree

Ans. A

Fill in the Blanks

1. In _____ force analysis, the inertia forces are also considered in addition to applied loads, the analysis is called (dynamic analysis)
2. _____ principle states that the inertia forces and couples and external forces and torques on a body together give statical equilibrium. (D'Alembert's Principle).
3. The Analysis of mechanism deals with _____ (The determination of displacement, velocity & acceleration in a mechanism).
4. A link AB is subjected to a force F (\rightarrow) at a point P perpendicular to the link at a distance a from the CG as shown in the figure. This will result in _____ (the CG and inertia both inertia force F (\rightarrow) through torque Fa (clockwise)
5. For analytical solution of mechanisms _____ links are considered as vectors. (moving links)
6. A disc is spinning with an angular velocity w rad/s about the axis of spin. The couple applied to the disc causing precession will be _____ ($I \omega \omega p$)
7. The difference between the desired motion and the actual motion produced is known as _____ error (structural).