Dynamics of Machinery

Two Mark Questions & Answers

Force Analysis

1. **Define inertia force.**
   Inertia force is an imaginary force, which when acts upon a rigid body, brings it to an equilibrium position. Mathematically,
   Inertia force = -Accelerating force = -m.a

2. **State D-Alembert's principle.**
   The resultant force acting on a body together with the reversed effective force (inertia force), are in equilibrium.

3. **What is a turning moment diagram?**
   The turning moment diagram (also known as crank-effort diagram) is the graphical representation of the turning moment or crank-effort for various positions of the crank. It is plotted in Cartesian co-ordinates, in which the turning moment is taken as y-axis and the crank angle in x-axis.

4. **Define coefficient of fluctuation of speed.**
   It is defined as the difference between the maximum and minimum speeds during a cycle. The ratio of the maximum fluctuation of speed to the mean speed is called the coefficient of fluctuation of speed.

5. **Give the equation for velocity of piston?**
   Velocity of piston $V = \omega.r.\ (\sin\theta + (\sin 2\theta)/2n)$

6. **What is the function of a flywheel?**
   The function of a flywheel is to store energy during excess supply and to release energy during the period when the requirement of energy is more than supply (or) a flywheel controls the speed variations caused by the fluctuation of the engine turning moment during each cycle of operation.

7. **Define coefficient of fluctuation of energy.**
   It is defined as the ratio of the maximum fluctuation of energy to the work done per cycle.
   C_E = Maximum fluctuation of energy / Work done per cycle

8. **Define maximum fluctuation of energy.**
   Maximum fluctuation of energy is defined as the difference between maximum energy and minimum energy in a flywheel.
   Maximum fluctuation of energy = Maximum energy – Minimum energy
9. **What are applied forces and constraint forces?**

The forces acting on links of a mechanism from outside are called as applied forces. When two ware more links are connected to form a pair and hence mechanism, the pair of action and reaction forces between any of two links are called constraint forces.

10. Give the equation for inertia force.

$$\text{Inertia force, } F_I = m_R .\omega^2.r. (\cos\theta + (\cos 2\theta)/n)$$

11. What are the conditions of equilibrium for a three force member?

Conditions are:

- The resultant of three forces should be zero.
- The line of action of the forces must intersect at one point known as point of concurrency.

12. Give four applications of flywheel.

i. Punching machines
ii. Riveting machines
iii. Shearing machines
iv. Crushers

13. Define coefficient of steadiness.

The reciprocal of the coefficient of fluctuation of speed is known as coefficient of steadiness and is denoted by m.

$$m = 1/C_s = N/ (N_1 - N_2)$$

14. Define crank effort.

Crank effort or turning moment or torque on crank shaft is defined as the product of the crankpin effort (F_T) and the crankpin radius(r).

$$\text{Crank effort } T = F_T \times r$$

15. State the principle of superposition.

In linear systems if number of loads act on a system of forces, the net effect is equal to the superposition of the effects of the individual loads taken one at a time.

16. Give the equation for acceleration of piston?

Acceleration of piston $a = \omega^2.r. (\cos\theta + (\cos 2\theta)/n)$

17. Give the equation for net load on piston for a horizontal engine?

Net load on piston = Load on piston – Inertia force – Frictional resistance

Net load on piston, $Fp = F_L - F_I - R_F$

18. Give the equation for net load on piston for a vertical engine?

Net load on piston = Load on piston – Inertia force – Frictional resistance + (Mass of reciprocating parts x gravity)

Net load on piston, $F_p = F_L - F_I - R_F + m_R.g$

19. What are the conditions of equilibrium for a two force member?

Conditions are:

i).The forces should be of same magnitude.

ii).The forces should act along the same line but opposite in direction.

20. Give the equation for thrust on bearings.

Thrust on bearings, $F_B = F_P . \cos(\theta + \Phi) / \cos \Phi$

Balancing

1. **What is balancing?**
   Balancing is the process of designing or modifying machinery so that the unbalance is reduced to an acceptable level and if possible is eliminated entirely.

2. **What are the types of balancing?**
   Balancing can be divided into the following types:
   - Balancing of rotating masses ,and
   - Balancing of reciprocating masses

3. **Give the condition for balancing several rotating masses in different planes.**
   Conditions are:
   - The resultant centrifugal force must be zero, and
   - The resultant couple must be zero.

4. **What is the need for balancing?**
   If the moving parts of a machine are not balanced completely, then the inertia forces are setup which may cause excessive noise, vibration, wear and tear of the system. So balancing of machines is necessary to eliminate them.

5. **What are the methods of balancing a single rotating mass?**
   Methods:
   - Introducing single revolving mass in the same plane, or
   - Introducing two revolving masses in different planes.

6. **What is static balancing?**
   A system of rotating masses is said to be in static balance if the combined mass centre of the system lies on the axis of rotation.

7. **What is dynamic balancing?**
   A system of rotating masses is in dynamic balance when there does not exist any resultant centrifugal force as well as resultant couple.

8. **What are the conditions for dynamic balancing?**
   Conditions are:
   - The net dynamic force acting on the shaft is equal to zero. This is the condition for static balancing.
   - The net couple due to the dynamic forces acting on the shaft is equal to zero.

9. **What are the types of locomotives?**
   According to the number of pairs of wheels attached:

- Coupled locomotive
- Uncoupled locomotive

Based on the arrangement of cylinders:

- Inside cylinder locomotive
- Outside cylinder locomotive

10. What are the effects due to partial balancing of reciprocating masses?

Effects are:

- An unbalance force along the line of stroke which produces,
- Variation in tractive force
- Swaying couple
- An unbalanced force perpendicular to the line of stroke which produces,
- Hammer blow (variation of pressure on the rails)

11. Define swaying couple.

The unbalanced forces acting at a distance between the lines of stroke of two cylinders, constitute a couple in the horizontal direction. This couple is known as swaying couple.

12. Define hammer blow.

The maximum magnitude of the unbalanced force along the perpendicular to the line of stroke is known as hammer blow.

13. What are the conditions for balancing reciprocating parts?

Conditions are:

- Primary forces must balance
- Primary couple must balance
- Secondary force must balance
- Secondary couple must balance

14. Give the expression for hammer blow.

Hammer blow = $B\omega^2 b$

15. Give the expression for primary unbalanced force acting on a piston?

Primary unbalanced force acting on a piston, $F_P = m\omega^2 r \cos\theta$

16. Give the expression for secondary unbalanced force acting on a piston?

Secondary unbalanced force acting on a piston, $F_R = m\omega^2 r (\cos 2\theta / n)$

17. When is the primary and secondary unbalanced forces maximum?

Primary unbalanced forces are maximum when crank angle is 0^0 and 180^0.

Secondary unbalanced forces are maximum when crank angle is 0^0, 90^0, 180^0 and 360^0.

18. Give the expression for maximum or minimum swaying couple?

Maximum or minimum swaying couple = $\pm a/\sqrt{2}\ ((1-c)\ m\omega^2\ r)$

19. Give the expression for variation of tractive force and when is it maximum?

Variation of tractive force, $F_T = ((1-c)\ m\omega^2\ r)\ [\cos\theta\ - \sin\theta\ ]$

Tractive force is maximum when $\theta = 135^0$ and 315^0

20. Give the expression for swaying couple.

Swaying couple, $T = a/2\ [(1-c)\ m\omega^2\ r\ (\cos\theta + \sin\theta)]$

CONTROL MECHANISMS

1. **What is the function of a governor?**
   The main function of a governor is to regulate the mean speed of an engine, when there are variations in the load.

2. **Give the classification of governors.**
   Governors are classified as follows:
   - Centrifugal governors
     - Pendulum type
     - Loaded type
   - Inertia governors

3. **Define height of a governor.**
   It is the vertical distance from the centre of the ball to a point where the axes of the arms intersect on the spindle axis.

4. **Define axis of precession.**
   The axis about which the axis of spin is to turn is known as axis of precession.

5. **Define equilibrium speed.**
   It is the speed at which the governor balls, arms etc., are in complete equilibrium and the sleeve does not tend to move upwards or downwards.

6. **Define mean equilibrium speed.**
   It is the speed at the mean position of the balls or the sleeve

7. **Define Stern.**
   The rear end of the ship is known as stern or aft.

8. **Define Port**
   The left hand side of the ship when viewed from the stern is known as port.

9. **What is active force?**
   When a body moves along a curved path with uniform linear velocity, a force in the direction of centripetal acceleration has to be applied externally over the body, so that it moves along the required curved path this external force applied is known as active force.

10. **What is reactive force?**
    When a body, itself ,is moving with uniform linear velocity along a circular path ,it is subjected to the centrifugal force radially outwards. This centrifugal force is called reactive force.

11. Define sleeve lift.

It is the vertical distance which the sleeve travels due to change in equilibrium speed.

12. Define precessional angular motion.

The angular motion of the axis of spin about the axis of precession is known as precessional angular motion.

13. What are the three axes involved in a gyroscope?

Three axes are a) Axis of spin, b) Axis of gyroscopic couple and c) Axis of precession.

14. Define hunting.

A governor is said to hunt if the speed of the engine fluctuates continuously above and below the mean speed.

15. Define Star board.

The right hand side of the ship when viewed from the stern is known as star board.

16. Define Steering.

Steering is the turning of a complete ship in a curve towards left or right, while the ship moves forward.

17. Define Bow.

The front end of the ship is known as bow.

18. What are the three types of movements a ship can have?

Types of movements are steering, pitching and rolling.

19. Define sensitiveness of governors.

It is defined as the ratio of the difference between the maximum and minimum equilibrium speeds to the mean equilibrium speed.

20. Define Pitching.

Pitching is the movement of a complete ship up and down in a vertical plane about transverse axis.

LONGITUDINAL VIBRATION

1. **What is vibration?**
   When elastic bodies such as a spring, a beam, and a shaft are displaced from the equilibrium position by the application of external forces, and then released, they execute a vibratory motion.

2. **Define time period.**
   It is the time interval after which the motion is repeated itself. The period of vibration is usually expressed in seconds.

3. **What are the means of reducing vibration?**
   Vibrations can be reduced by:
   Providing dampers such as rubber, metal and shock absorbers
   Balancing the rotating and reciprocating parts in the system.

4. **Define damping co-efficient.**
   It is defined as the resisting force developed per unit velocity of viscous fluid.

5. **What is damped vibration?**
   When there is a reduction in amplitude over every cycle of vibration, the motion is said to be damped vibration.

6. **What is free vibration?**
   When no external force acts on the body , after giving it an initial displacement, then the body is said to be under free or natural vibration.

7. **Define amplitude reduction factor.**
   It is defined as the ratio of any two successive amplitudes on the same side of the, mean position.

8. **Define frequency.**
   It is defined as number of cycles described in one second. It is usually expressed in cycles per second

9. **Define damping ratio.**
   The ratio of the actual damping coefficient to the critical damping coefficient is defined as damping ratio.

10. **Differentiate longitudinal and transverse vibrations.**

Vibrations which occur along the axis of the shaft or spring are known as longitudinal vibrations. The vibrations which occur in the direction approximately perpendicular to the axis of the shaft are known as transverse vibrations.

11. Define logarithmic decrement.

It is defined as the natural logarithm of the amplitude reduction factor.

12. Define critical speed.

The speed at which the shaft runs so that the additional deflection of the shaft from the axis of rotation becomes infinite, is known as critical speed or whirling speed.

13. What are the causes of vibration?

The main causes of vibrations are:

- Unbalanced forces and couples in the machine part.
- External excitation applied on the system.
- Winds, earth quakes, etc.

14. What are the effects of vibrations?

Effects are:

- Excessive stress in vibrating parts
- Undesirable noise
- Failure of parts.

15. What are the applications of vibration?

Applications are in:

- Musical instruments
- Vibrating screens and conveyors
- Stress relieving equipments

16. What is damping?

Damping is defined as the resistance to vibration.

17. What are the types of vibrating motions?

Types are:

- Free vibration
- Forced vibration
- Damped vibration

18. What are the types of vibration?

- Longitudinal vibration
- Transverse vibration
- Torsional vibration

19. Define viscous damping.

Viscous damping is defined as the resistance offered by a viscous fluid to the vibrating system.

20. What is forced vibration?

When the body vibrates under the influence of external force, then the body is said to be under forced vibrations.

21. Define resonance.

When the frequency of external excitation force acting on the body is equal to the natural frequency of a vibrating body, then the amplitude of vibration becomes infinite and hence it causes failure of body. This is known as resonance.

TRANSVERSE & TORSIONAL VIBRATIONS

1. **What is transverse vibration?**
   The vibrations which occur in a direction approximately perpendicular to the axis of the shaft are known as transverse vibrations.

2. **What is torsional vibration?**
   The vibrations which occur in a circular path along the axis of the shaft are known as torsional vibrations.

3. **What are the conditions to be satisfied by an equivalent shaft geared system?**
   Conditions:
   - The kinetic energy of the equivalent system must be equal to the kinetic energy of the original system.
   - The strain energy of the equivalent system must be equal to the strain energy of the original system.

4. **Explain the term 'elastic line' in a two rotor system.**
   The line connecting the amplitudes of the two rotors and which passes through the node in the nodal diagram is known as the elastic line.

5. **Explain the term torsionally equivalent shaft.**
   The original shaft with varying diameters is being replaced by a theoretical shaft of uniform diameter in order to find the node, this theoretical shaft is known as equivalent shaft.

6. **Define the term node.**
   It is defined as the point or section of the shaft which remains untwisted or at which the amplitude of vibration is zero.

7. **Define magnification factor.**
   It is defined as the ratio of maximum displacement of the forced vibration to the deflection due to the static force.

8. **What are the assumptions made in calculating the free torsional vibrations of a geared system?**
   Assumptions:
   - The gear teeth are rigid and are always in contact
   - There is no backlash in the gearing
   - The inertia of the shafts and gears are negligible.

9. **Give the expressions to locate the node in a two rotor system.**

Length of shaft, $L = L_A + L_B$

$L_A . I_A = L_B . I_B$

10. Name some vibration isolating materials.

Vibration isolating materials are:

- Rubber dampers
- Metallic dampers
- Dashpots.

11. Define transmissibility.

It is defined as the measure of effectiveness of the vibration isolating system. It is the ratio of force transmitted to the foundation to the applied force.

12. What is vibration isolation?

Vibration isolation is the method of reducing vibrations by providing proper dampers.

13. Give the expression for critical speed of a shaft.

Critical speed $N_s = 0.4985/\sqrt{\delta}$ r.p.s.

14. What are the assumptions made for the supports according to the type of bearings?

A shaft supported in short bearings is assumed to be a simply supported shaft while the shaft supported in long bearings is assumed to have both ends fixed.

15. Give the expression for the natural frequency of a system.

Natural frequency $f=0.4985/ \sqrt{[\delta_1 + \delta_2 + \ldots\ldots + (\delta_s/1.27)]}$