PHY2B02:MECHANICS-2

A Part

1. Explain hypothesis of Galilean invariance.
2. Distinguish between inertial and non-inertial frame of reference.
3. Write down the Galilean transformation equations.
4. What is meant by non inertial frame?
5. How does the path of a point on the rim of a rolling wheel look like to an observer (a)standing at the centre of the wheel (b)standing on the ground?
6. Show that Newton's second law of motion is invariant under Galilean transformation.
7. Write down Galilean velocity transformation equations.
8. Define an inertial frame.
9. What is fictitious force? Explain with example.
10. When a small mass m hanging on a string in a car, which accelerates at rate A, draw force diagram in both inertial frame and in a frame accelerating with the car
11. Explain how the fictitious force in uniformly accelerating systems acts like gravitational forces
12. Explain the concept that objects inside the aircraft will experience weightlessness during the time of free fall.
13. What is the principle of equivalence?
14. What are tides and how are they formed?
15. What is centrifugal force? Give an example.
16. What is coriolis force? Give an example
17. What are the effects of acceleration of a lift on the weight of a person inside it?
18. What is the tension acting on the string of a body hanging in a moving car?
19. Show that even if no external force is acting, a particle will experience a force in an accelerated frame.
20. Why cyclones are not present in the equator region ?
21. What happens to a freely falling body under the coriolis force of earth
22. Write the expressions for Coriolis acceleration and Centrifugal acceleration.
23. What is the effect of centrifugal acceleration due to Earth's rotation on acceleration due to gravity?
24. Why the tide winds are shifting to north - west and south-West?
25. What is Foucault pendulum?

26. What is the theory of Foucault's pendulum?

27. Give the expression for the time period of rotation of plane of oscillation of a Foucault's pendulum. What is this rotation due to?

28. What are the consequences of coriolis force due to spin rotation of earth on the water and air flow on earth?

29. What are isobars and what is its importance?

30. Name two constants of motion in central force problem.

31. Show that when a particle moves under a central force, its angular momentum is conserved.

32. Prove that angular momentum of a particle moving under Central force is conserved

33. Show that when a particle moves under a central force, it moves in a plane

34. A planet moves faster when it passes close to the sun. Why?

35. How two body problem reduced to one body problem?

36. write two equivalent expressions for the total energy in the centre of mass system

37. What is the significance of the constancy of areal velocity?

38. What is meant by a constant of motion?

39. Discuss various nature of motion determined by total energy E

40. What are the properties of central fore?

41. Write any two properties of central force motion

42. What are central forces? Give an example

43. Write the equation of areal velocity of a planet around the sun.

44. Draw the energy diagram of a meteor passing near a planet in different energy cases

45. Write down the relation between r_{max} , r_{min} and eccentricity ϵ

46. What is an energy diagram?

47. Write an expression of kinetic energy associated with radial motion.

48. Draw the variation of energy with distance in the case of two non interacting particles m_1 and m_2 moves parallel towards each other with velocities v_1 and v_2.

49. Write the condition of ecccentricity equation of orbit for a parabolic orbit.

50. Write down the relation between energy and eccentricity.

51. Write the condition for an elliptic orbit becomes circle.
52. Define eccentricity of an orbit.
53. Write the condition of ecccentricity equation of orbit for a elliptic orbit.
54. Explain the terms perigee and apogee.
55. Which parameter characterizes the shape of the orbit? Write the expression for it.
56. State the Keplers law of equal areas
57. Define impact parameter and the distance of closest approach.
58. State Kepler's laws of planetary motion.
59. State Kepler’s third law. Write the expression for it.
60. Write down the expression for the time period of a planet and explain the symbols.
61. State the law of periods.
62. write any two examples of harmonic oscillators
63. Define Simple Harmonic Motion. Give examples.
64. Write two examples for harmonic oscillators with time period equation.
65. write the expression for period of simple pendulum and compound pendulum
66. What is free oscillation ?
67. Write down the differential equation for a simple harmonic oscillatorand its standard solution.
68. Explain the concept of damping force, write two examples.
69. Define damping coefficient and damping constant
70. Draw potential, kinetic and total energies as a function of displacement in a harmonic oscillator
71. Which are the factors on which the total energy of a particle executing SHM depend?
72. Using initial conditions, obtain an expression for phase angle.
73. Draw graphically kinetic energy and potential energy as a function of displacement
74. Give the condition on the damping constant for which a harmonic motion is over damped
75. What is damped oscillation?
76. What is the difference between critically damped and under damped situations
77. Give the condition on the damping constant for which a harmonic motion is critically damped.
78. What is meant by a damped harmonic oscillator. Give examples.

79. What is the relaxation time of a damped harmonic oscillator?
80. Give the condition on the damping constant for which a harmonic motion is under damped.
81. which are the forces acting on damped simple harmonic oscillator.
82. Show that the total energy of particle executing simple harmonic motion is directly proportional to the square of the amplitude.
83. Draw the variation of displacement of damped oscillator with time.
84. What is logarithmic decrement?
85. Write the relation connecting quality factor and relaxation time.
86. What is the Quality factor of an oscillator?
87. Write the relation connecting logarithemic decrement and relaxation time.
88. What is an undamped driven oscillator? Give examples
89. Write the differential equation of a forced harmonic oscillator and explain the terms involved in it.
90. What is meant by a forced harmonic oscillator. Give examples.
91. What is the condition under which forced oscillations are produced.
92. Differentiate between longitudinal and transverse waves.
93. Differentiate between travelling wave and standing wave.
94. What is a harmonic wave?
95. What is meant by closed and open systems?Give examples.
96. State two important properties of travelling waves.
97. Comment on superposition of wave pulses. A pulse shape with sharp corners (like trapezoid,) is impractical.Why?
98. Define a wave.
99. What is phase velocity?
100. Explain the concept of wave number.
101. What are the differences between travelling and standing wave?
102. Differentiate between mechanical and non-mechanical waves.
103. What is dispersion law?
104. What are the Dirichlet's conditions to be satisfied for a function to be expanded into Fourier components?
105. Distinguish between dispersive and non-dispersive media?
106. What is snell's law?
107. Explain the connection of wave velocity with thermodynamic variables like P, V, T etc.
108. What is dispersion?

109. What is meant by a harmonic wave?

110. Write wave equation for a travelling wave in (i) one dimension (ii) two dimension (iii) three dimension

111. What are standing waves? Explain different modes.

112. Give the expressions for group velocity and phase velocity.

113. Discuss the speed of sound waves in liquids and gases.

114. Define bandwidth.

115. What is meant by bandwidth of an A M wave?

116. Discuss the speed of sound waves in solid bars and liquid.

117. Define the lower and upper side band of a frequency spectrum.

118. What is pulse in wave motion?

119. What is a pulse?Give example.

120. Write down the Fourier series for the periodic function F(t).

B Part

121. Calculate the fictitious force on a body of mass of 5 kg in a frame of reference moving vertically up with an acceleration 4m/s^2

122. Explain the motion of a pendulum in a car from the point of view of a passenger in the car and from an inertial frame outside car.

123. Derive a relation for the deflection of body of mass m dropped from a height h at the equator.

124. A stone dropped with zero initial velocity from the top of a 100m high tower at the equator. Calculate the horizontal displacement of the stone due to earth rotation.

125. Explain the working of Foucault pendulum.

126. Show that the areal velocity is a constant in a central force field.

127. A particle of mass 50 kg moves under an attractive central force of magnitude $4r^3$ Newtons. The angular momentum is equal to 5000 kg m^2/s. (a) Find the effective potential energy. (b) The radius of the particle's orbit varies between r_0 and $2r_0$. Find r_0.

128. Obtain an expression for the total energy of a particle in a central force field.

129. How can we reduce a two body problem to a one body problem?

130. Show that orbits with same major axis have same energy in gravitational interaction of planets around the sun.

131. Draw the energy diagram of a meteor passing near a planet and explain the different cases based on total energy.

132. Show that in real situations in a central force field, the angular momentum and energy of the actual two particle problem and the equivalent one particle problem are the same.

133. Discuss three different trajectories depending on eccentricity Є in the case of planetory motion.

134. A particle of mass m moving under a central force $F = kr^2$ has angular momentum L. Find the position where potential energy is minimum

135. A particle moves in a circular orbit in a force field $F(r) = -\frac{k}{r^2}$. Suddenly k becomes $\frac{k}{2}$ without change in velocity. What will be the shape of the new orbit?

136. Write down the expression for the eccentricity of an orbit. What is its relevance?

137. Obtain an expression for angle of asymptotes in the case of unbounded motion of a comet with reduced mass μ around the sun with a velocity v_0.

138. If the earth be one half its present distance from the sun, how many days will be in one years.

139. A satellite of mass 2000kg is in elleiptical orbit around the earth. At perigee, it has an altitude of 1100km and at apogee its altitude is 4100km. What are the satellites energy and angular momentum?

140. Define impact parameter. Obtain an expression for impact parameter in the case of unbounded motion of a comet with reduced mass μ around the sun with a velocity v_0.

141. The mean diameter of moon's orbit around the earth is 7.6 x 10^5km and orbital period is 27 days. Using these data calculate the period of revolution of an artifcial satellite in an orbit of radius 10^4km around the earth.

142. The mean distance of Mars from the Sun is 1.524 times that of the earth from the sun. How many years would be required for mars to make one revolution around the sun?

143. A planet moves faster when it passes close to the sun. How will you understand this on the basis of the relevant Kepler's law?

144. A Saturn year is 29.5 times the earth year. How far is saturn from the sun if the earth is 1.5 x 10^8 km away from the sun?

145. Calculate the mass of the sun given that the mean distance between the sun and the earth is 1.49x 10^8km, the period of revolution of earth is 365 days and G= 6.67 x 10^{-11}N m^2 kg^{-2}.

146. The distance of the planet Jupitar from the sun is 5 times that of the earth. Find the period of Jupiters revolution around the sun.

147. Periods of revolution of the Planets Earth, Mercury and Mars are 365.26, 87.97 and 687.05 days. Find the major axes of the orbits of Mercury and Mars if the major axis of earth is 300x10^6km.

148. Write the expressions for time period, frequency, angular frequency and displacement of a particle executing SHM

149. Write the standard form of the solution of linear harmonic oscillator. By applying initial conditions of time, position and velocity , obtain an expression for initial phase angle ϕ.

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150. Show that the average value of potential energy over a cycle in a SHM is the half of its total energy.

151. Show that the average value of kinetic energy over a cycle in SHM is the half of its total energy.

152. Show that the total energy of simple harmonic motion is a constant or it is equivalent to maximum kinetic energy

153. Calculate the average energy stored in a 20 gm mass attached to a spring and vibrating with an amplitude 1 cm in resonances with a periodic force whose frequency is 20 Hz. If the quality factor of the oscillator be 160, how much energy is dissipated per second

154. Show that average value of kinetic energy and potential energy over a cycle in simple harmonic motion are equal.

155. Draw the displacement-Time graph of damped LHO

156. A 0.3kg mass is attached to a spring and oscillates at 2Hz with a Q of 60. Find the spring constant and damping constant.

157. Draw the variation of amplitude in undamped oscillator and exponentially damped oscillator

158. A damped vibrating system starting from rest reaches a first amplitude of 50cm, which reduces to 5cm after 100 oscillations, each of period 2.3 seconds. Find the damping constant, relaxation time and correction for the first displacement for damping

159. What are the different types of damping? Discuss in detail the critically damped case.

160. Show that in the presence of damping force, velocity of an oscillating particle decreases exponentially

161. Show that the energy of the damped oscillator falls to 1/e of the initial value in a time $t = 1/\gamma$

162. State the conditions for under damped, critically damped and over damped harmonic oscillations.

163. A damped vibrating system starting from rest reaches a first amplitude of 50 cm, which reduces to 5 cm after 100 oscillations, each of period 2.3 seconds. Find the damping constant and correction for the first displacement for damping.

164. Deduce an expression for Q factor for a damped oscillator and discuss its value in the case of lightly and heavily damped oscillator.

165. What is Logarithmic decrement? From logarithmic decrement, how will you calculate the damping coefficient?

166. A tuning fork has frequency 440Hz. A sound level meter indicates that the sound intensity decreases by a factor of 5 in 4 sec. What is the Q of the tuning fork?

167. Obtain the solution of equation of motion of a driven harmonic oscillator.

168. The time period of pendulum is 2 sec. If the angular retardation due to air is 0.04 times the angular velocity of the pendulum and the original amplitude is 1, calculate the amplitude after 10 oscillations

169. What is Q-factor. Give its expression in damped harmonic oscillator.

170. The logarithmic decrement δ is defined to be the natural logarithm of the ratio of successive maximum displacements (in the same direction) of a free damped oscillator. Show that $\delta = \pi/Q$.

171. When a paper weight suspended from a rubberband had a period of 1.2 sec and the amplitude of oscillation decreased by a factor of 2 after three periods. What is the estimated Q of the system.

172. The frequency of a tuning fork is 300 Hz. If its quality factor Q is 1000, find the time after which its energy becomes 1/10 of its initial value.

173. Obtain the expression for Quality factor of a damped harmonic oscillator

174. For a forced harmonic oscillator, the amplitude of vibrations increases from 0.02mm at very low frequencies to a value 5mm at the frequency 100Hz. Find (i) Q factor of the system (ii) damping constant k and relaxation time (iii) half width of resonance curve

175. Explain resonance. Give examples.

176. A constant torque of 8×10^{-5} N-m produces an angular displacement of 2^o in a torsion pendulum whose moment of inertia is 10^{-3} kgm^2. Calculate the frequency of the periodic external torque which will produce resonance.

177. Obtain an expression for amplitude interms of driving frequency . Explain how the amplitude varies with driving frequency.

178. Draw the frequency - amplitude curve of a driven oscillator and explain it.

179. Starting from the equation k=2π/λ, prove that phase velocity=λ/T

180. A typical string in a piano is made of steel with a radius r=0.50mm and density 7800 kg/m^3. It has a tension of about 650 N. What is the speed of a wave on such a string?

181. Explain the motion of travelling harmonic waves in one dimension.

182. Obtain the equation for the wave envelope in case of superposition of two progressive waves.

183. A steel wire of 0.72 m long has a mass of 5×10^{-3} kg. If the wire is under a tension of 60N what is the speed of transverse waves on the wire?

184. Prove that group velocity is given by $\frac{dw}{dk}$

185. A string for which $\mu=5*10^{-2}$ kg/m is under a tension of 80 N. How much power must be supplied to the string to generate sinusoidal waves at a frequency of 60 Hz and an amplitude of 6 cm?

186. Explain the superposition of two harmonic oscillations having equal amplitudes,but slightly different frequencies.

187. Obtain the relation between phase velocity and group velocity.

188. Find the Fourier expansion for the following periodic function.

$$f(t) = \begin{cases} -1 \text{ for } \frac{-T}{2} \le t < 0 \\ 1 \text{ for } 0 \le t < \frac{T}{2} \end{cases}$$

189. What is group velocity? What is its significance ?

190. Suppose a wave on a string is described by the equation y=0.040 cos (25t-30x) where the units of t are seconds and x is given in meters. Find the amplitude, frequency,wavelength, and velocity of this wave.

191. Derive an expression for phase velocity and group velocity.

192. A metal wire of 4m length and 0.2mm radius fixed vertically at one end. At the lower end, a 10 kg mass is suspended. As a result, it elongates by 15.5mm. The density of the metal is $7800 kg/m^2$.If the transverse waves are now send through this wire, find its velocity.

193. The dispersion relation for a wave is given by the equation $\omega = Ak^2$, where A is a constant.Find phase and group velocities for the wave.

194. Use the Fourier analysis to analyse the square wave pulse.

$$f(x) = \begin{cases} x & 0 \leq x < \pi \\ x-2\pi & \pi \leq x < 2\pi \end{cases}$$

195. Check whether the following functions can be solutions to the 1-dimensional wave equation:
(a) $x^2+v^2t^2$
(b) $x^2-v^2t^2$
(c) 2sinxcosvt

196. Obtain the exact equation for a pulse wave form using Fourier analyses

C Part

197. Discuss the formation of tides in the ocean

198. Derive an expression for all the fictitious forces acting on a particle moving with velocity V in a rotating frame which is itself rotating with a uniform angular velocity ω with respect to another inertial frame.

199. Explain the effect of coriolis force on a particle in vertical motion and horizontal motion

200. Discuss the origin of fictitious force in rotating co-ordinate systems. Hence discuss the geographical consequences of coriolis force on earth

201. What is coriolis force? Explain the role of coriolis effect in weather systems

202. What are central forces? Discuss the general properties of motion under central force.

203. Discuss the problem of two non-interacting particles moving parallel to each other. What is the e ective potential. Draw the energy level diagram.

204. Find an expression for orbits of planets around the sun.

205. Discuss the motion of a comet around the sun.

206. State Kepler's laws of planetary motion. Derive the law of periods.

207. Set up the differential equation for a damped harmonic oscillator and solve it for different damping factors.

208. Solve the differential equation of damped harmonic oscillator with all cases and discuss in detail the under-damped case

209. Show that only under the action of damping force, its kinetic energy decreases exponentially in time. Draw the graphical representation of decay of energy.

210. Write the equation of motion of the forced oscillator. Derive an expression for amplitude of the forced oscillator. Explain its dependence on the frequency of the applied force.

211. Set up the differential equation for a forced harmonic oscillator and solve it. Hence obtain the condition for resonance.

212. What is a wave? Explain the different modes possessed by the standing wave and show that standing waves can be represented by two waves travelling in opposite direction.

213. Derive an expression for energy associated with a mechanical wave.

214. Explain Fourier expansion of a pulse. What are the conditions to be satisfied by a disturbance for it to be Fourier expanded?

215. Discuss the superposition of wave pulses and derive expression for phase velocity and group velocity .

216. What is a pulse? Discuss Fourier analysis of a periodic function with suitable example.

217. Derive an expression for the work done by a driving agent which results in progressive waves.

D Part

E Part