QP CODE: D4BPH2402	(Pages: 3)	Reg. No	: ....
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FOURTH SEMESTER FYUGP EXAMINATION, APRIL 2026

Discipline Specific Core (DSC) Courses - Major

PHY4CJ204 : MECHANICS– II

(Credits: 4)

Time: 2 Hours	Maximum Marks: 70

Section A

Answer the following questions. Each carries 3 marks (Ceiling: 24 marks)

1.	Identify the force law corresponding to $V_{\text{eff}} = \frac{l^2}{2mr^2} - \frac{k}{r}$.	BL1	CO1
2.	Write the expression for the period of an elliptical orbit.	BL1	CO1
3.	Describe the perturbation method used to solve for the motion of a falling body under the influence of the Coriolis force. What is the "zeroth-order approximation"?	BL1	CO5
4.	Define the effective gravitational acceleration $\mathbf{g}_e$ and explain how it incorporates the centrifugal acceleration due to Earth's rotation.	BL1	CO5
5.	Write the relationship between the position vectors of a particle as seen from an inertial frame O and a linearly accelerating frame O′.	BL1	CO5
6.	Write the auxiliary (characteristic) equation obtained by substituting the trial solution $x = e^{pt}$ into the damped harmonic oscillator equation $m\ddot{x} + b\dot{x} + kx = 0$.	BL2	CO2, CO3
7.	Describe the phenomenon of resonance in the context of a forced undamped harmonic oscillator. What happens to the amplitude of the particular solution as the driving frequency ω_d approaches the natural frequency ω_0?	BL2	CO2, CO3
8.	Describe how a standing wave can be mathematically constructed as the superposition of two traveling waves moving in opposite directions.	BL2	CO4
9.	If a wave travels from a lighter string into a heavier string $(\rho_2 > \rho_1)$, what happens to the amplitude and phase of the reflected wave?	BL2	CO4
10.	Compare and contrast standing waves and traveling waves in terms of their mathematical representations and physical behaviors.	BL3	CO4

(PTO)

Section B

Answer the following questions. Each carries 6 marks (Ceiling: 36 Marks)

11.	Set up the integral for the time required for a planet to move from perihelion to aphelion in an elliptical orbit. Express the integral in terms of a, e, G, M, and m, and explain why it is not trivial to evaluate analytically.	BL3	CO1
12.	For an elliptical orbit, show that the total energy E is related to the semi-major axis by $E = -\frac{GMm}{2a}$. Use the relationships between E, l, a, and e.	BL3	CO1
13.	Write the general complex solution $\zeta(t) = x(t) + iy(t)$ for the Foucault pendulum equations. Show that it satisfies $\ddot{\zeta} + 2iK\dot{\zeta} + \omega^2\zeta = 0$ and find the characteristic roots assuming $K \ll \omega$.	BL1	CO5
14.	Using the orbit equation, compute the speed v of a planet at any point in its elliptical orbit. Show that $v^2 = GM\left(\frac{2}{r} - \frac{1}{a}\right)$ and verify that it satisfies energy conservation.	BL3	CO1
15.	Starting from Kirchhoff's voltage law, derive the differential equation for the charge $q(t)$ in a series LRC circuit with an applied voltage $V_0\cos(\omega t)$. Show that it takes the form $L\ddot{q} + R\dot{q} + (1/C)q = V_0\cos(\omega t)$. Identify the terms analogous to inertia, damping, and restoring force in the mechanical oscillator equation.	BL3	CO3, CO4
16.	Starting from Newton's second law, derive the differential equation $m\ddot{x} + kx = 0$ for a mass on a spring on a frictionless horizontal surface. Then, using the ansatz (assumed trial solution) $x = e^{pt}$, derive the auxiliary equation and show that it leads to the solution $x(t) = A\cos(\omega t + \beta)$ where $\omega = \sqrt{k/m}$.	BL3	CO2
17.	Derive the formulas for the Fourier coefficients a_m and b_m for a function $f(x)$ defined on the interval $-\pi < x < \pi$ starting from the general Fourier series $f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty}[a_n\cos(nx) + b_n\sin(nx)]$. Use the orthogonality relations of sine and cosine functions.	BL3	CO4
18.	Show that an expression of the form $y = A\sin kx + B\cos kx$ can be rewritten as $y = C\cos(kx + \alpha)$. Express C and α in terms of A and B and explain the physical significance of α.	BL3	CO4

Section C

Answer any one question. Each carries 10 marks (1 x 10 = 10 Marks)

19.	Derive the radial equation of motion for a particle of mass m under a central force $F = f(r)\hat{\mathbf{r}}$, starting from Newton's second law in polar coordinates. Hence, show that the angular momentum is conserved. $[\ddot{r} - r\dot{\theta}^2 = f(r)/m, \quad l = mr^2\dot{\theta} = \text{constant}]$	BL2	CO1

20.	Derive the equation of motion for a simple harmonic oscillator consisting of a mass m attached to a spring of constant k on a frictionless horizontal surface. Begin by stating the expressions for kinetic energy T and potential energy V for this system. Form the Lagrangian $L = T - V$. Use Lagrange's equation, $\frac{d}{dt}\frac{\partial L}{\partial \dot{x}} - \frac{\partial L}{\partial x} = 0$, to obtain the differential equation $m\ddot{x} + kx = 0$. Finally, describe the physical significance of this equation and the meaning of its solution $x(t) = A\cos(\omega t + \beta)$, where $\omega = \sqrt{k/m}$.	BL2	CO2
	CO : Course Outcome		
	BL : Bloom's Taxonomy Levels (1 – Remember, 2 – Understand, 3 – Apply, 4 – Analyse, 5 – Evaluate, 6 – Create)		