Ministry of Higher Education
& Scientific Research
AlMuthanna University
College of Science
Department of physics

Subject: Adv. Q. Mechanics
Stage: MSC

Date: / /2019
Time : 3 H

21. 10. 2019

45

((Assessment of the final exam for the first semester))
Academic year 2018-2019

Q1. Consider a particle of a mass m subjected to the Hamiltonian

$$H = \begin{cases} \frac{p^2}{2m} + \frac{m\omega^2 r^2}{2} & ; 0 \le r \le a \\ \frac{p^2}{2m} & ; r > a \end{cases}$$

where $r = \sqrt{x^2 + y^2}$. Use the second-order perturbation to find the corrections to the ground state energy. (12M)

Q2. Consider a harmonic oscillator with a force constant k and a reduced mass m.
The small perturbation $W = ax^3$ is applied to the oscillator. Compute the first order correction to the wave functions and first nonvanishing correction to the energies.
(10M)

Q3. Obtain the matrix of Clebsch-Gordan coefficients when two angular momenta $j_1 = 1/2$ and $j_2 = 1/2$ are coupled. (12 M)

Q4. Consider a one-dimensional harmonic oscillator: (a) For the one-parameter family of wave functions $\psi_\gamma(x) = \frac{1}{x^2 + \gamma}$; $(\gamma > 0)$, find a wave function that minimizes $< H >$. What is the value of $< H >_{min}$. (b) Repeat the same procedure for $\psi_\beta(x) = x\exp(-\beta x^2)$. (12M)

Q5. Calculate the matrix representation of the angular momentum operators J_x, J_y, J_z, and J^2, for the values $j = \frac{1}{2}, 1, \frac{3}{2}$, respectively. (12M)

Q6. A. Show that for a harmonic oscillator, the matrix elements of operator p is given,

$$< n'|p|n > = i\sqrt{\frac{m\hbar\omega}{2}}\left(\sqrt{n+1}\,\delta_{n',n+1} - \sqrt{n}\,\delta_{n',n-1}\right)$$

B. Show that: $[J_z, J_+^n] = n\hbar J_+^n$ (12M)

Good Luck

Lecturer
Dr. Hadey K. Mohamad

Head of Department

الفيزياء / ماجستير / رياضية

Ministry of Higher Education
& Scientific Research
Al-Muthanna University
College of Science
Department of Physics

Subject :Mathematical physics
Stage :M.Sc
Date: / /2019
Time :three hours

15. 10. 2019

45

((Assessment of the final exam for the first semester))
Academic year 2018 -2019

Q1// **(14 Mark)**

(i) By Caley-Hamilton theorem ,find A^{-1} of the matrix $A = \begin{pmatrix} cos\theta & sin\theta \\ -sin\theta & cos\theta \end{pmatrix}$,then show that if $0 < \theta < \pi$,then A^{-1} has no real Eigen values and consequently no Eigen vectors.

(ii) Show that $x^3 = \frac{2}{5}p_3(x)\frac{3}{5}p_1(x)$, where $p_n(x)$ is Legendre polynomial .

Q2// **(12 Mark)**

(i) find the first three terms of Tayler series expansion of $f(z) = \frac{1}{z^2+4}$ about $z = -i$, find the region of convergence.

(ii) if $D=P^{-1}AP$ then $D^n= P^{-1}A^nP$ where A is a square matrix and P is a non-singular matrix .

Q3// **(14 Mark)**

(i) determine the poles of the following function and residue at each pole

$\int \frac{(12z-7)dz}{(z-1)^2(2z+3)}$ where C is the circle: (a) $|z| = 2$ (b) $|z + i| = \sqrt{3}$

(ii) if A^{ij}_k and B^{lm}_n are tensors then their sum and difference are tensors of the same rank and type.

Q4// **(15 Mark)**

(i) calculate $\oint \frac{(2z^2+5)dz}{(z+2)^3(z^2+4)}$, where C is the square with the vertices at (1+i),(2+i),(2+2i),(1+2i).

(ii) if $\emptyset = a_{jk}$ A^jA^k show that we can always write if $\emptyset = b_{jk}$ A^jA^k where b_{jk} is symmetric.

(iii) prove that $x^2J''n(x) = (n^2 - n - x^2)J_n(x) + x\,J_{n+1}(x)$

Q5// **(15 mark)**

(i) An electrostatic field in the xy-plane is given by the potential function $\zeta = x^2 - y^2$. Find the stream function.

(ii) solve $(1 - x^2)\frac{d^2y}{dx^2} - 2x\frac{dy}{dx} + 2y = 0$ in series.

(iii) find a matrix P which diagonalizes the matrix $A = \begin{bmatrix} 4 & 1 \\ 2 & 3 \end{bmatrix}$ verify $P^{-1}AP = D$.

M.M.KRADY
Lecturer
Assist.Prof. Mousa Makey Krady

Head of Department

العنز ١٠ / كلا سيكي متقدم

Ministry of Higher Education
& Scientific Research
AlMuthanna University
College of Science
Department of physics

Subject: Adv. Classical Mecanics
Stage: MSc.

Date: / / 2019 15. 10. 2019
Time : 3 hr.

45

((Assessment of the final exam for the first semester))
Academic year 2018 -2019

Q1// By using Definitions of D Alembert's find the relation for Lagrange equation? (14 marks)

Q2// A) Defined the constraints? What are the types of it and described it? What are the difficulties of constraints (8Marks)

B) Satisfying the relation $\vec{N} = \dot{\vec{L}}$ where ,N, is torque and ,L, is angular momentum ? (6 Marks)

Q3// Use the (x,y) coordinate system of Fig(1) to find the kinetic energy, potential energy, and the lagrangian for a simple pendulum (length l, mass bob m) moving in the x,y plane. Determine the transformation equations from the (x,y) rectangular system to the coordinate , Find the equation of motion. (14Marks)

Q4// // investigate the stability of circular orbits in a force field described by the Potential function: (14Marks)

$$U(r) = \frac{-k}{r^2} e^{-(2r/a)}$$

Q5// A particle of mass m starts at rest on top of a smooth fixed hemisphere of radius a (See Fig.2) . Find the force of constraint, and determine the angle at which the particle leaves the hemisphere? (14Marks)

Lecturer
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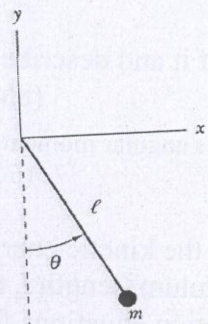

Fig.(1)

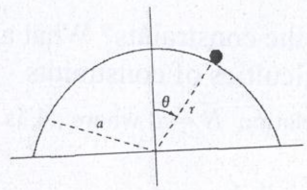

Fig.(2)

Good Luck

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