STELLA MARIS COLLEGE (AUTONOMOUS) CHENNAI – 600 086
(FOR candidates admitted from the academic year 2019-2020 & thereafter)

SUBJECT CODE : 19PH/MC/MP44

B.Sc. DEGREE EXAMINATION – APRIL 2022
BRANCH III – PHYSICS
FOURTH SEMESTER

COURSE : MAJOR CORE
PAPER : MATHEMATICAL PHYSICS
TIME : 3 HOURS **MAX. MARKS : 100**

SECTION – A

ANSWER ALL QUESTIONS:

I CHOOSE THE CORRECT ANSWER: (10 x 1 = 10)

1. The angle between the vector $\vec{A} = \vec{j}$ and the Z axis is
   a) 30^o b) 0^o c) 17^o d) 90^o
2. If three vectors a , b, c are coplanar
   a) a x b x c = 0 b) a . b x c = 0 c) a x b . c = 0 d) a . b . c = 0
3. Given the vector E = yz i + xz j + xy k, it is
   a) solenoidal b) irrotational c) null d) infinite
4. A particle moves so that its position vector $\vec{r}$ is given by $\vec{r} = \vec{i}\cos\omega t + \vec{j}\sin\omega t$ where ω is constant. If $\vec{v}$ is the velocity of the particle, then $\vec{r}.\vec{v}$ is equal to
   a) ω b) 0 c) r d) v
5. For a surface ϕ(x,y,z)=c, where 'c' is a constant, $\hat{\nabla}\phi$ is
   a) a null vector b) unit vector
   c) a vector parallel to the surface d) a vector perpendicular to the surface
6. Work done in moving the vector $r = 3\vec{i} + 2\vec{j} - 5\vec{k}$ if applied force is $F = 2\vec{i} - \vec{j} - \vec{k}$ is
   a) 1 b) 21 c) 9 d) none
7. Gauss's law in electrostatics in differential form is given by
   a) div $E = \rho/\varepsilon_0$ b) div E= ρ c) E.ds= ρ/ε_0 d) E.ds= ρ
   where ρ is the charge density, E the electrostatic field and ε_0 the permittivity of free space.
8. A necessary and sufficient condition that the integral $\int_c A.dr = 0$ for every closed curve C is that
   a) div A = 0 b) curl A = 0 c) div A ≠ 0 d) curl A ≠ 0

….2

9. As per stokes theorem

a) $\int_s \nabla x A.ds = \int A.dr$ b) $\int_s \nabla A.ds = \int A.dr$

c) $\int_s \nabla^2 A.ds = \int A.dr$ d) $\int_s \nabla^2 xA ds = \int A.dr$

10. Product of a complex number and its conjugate is

a) imaginary b) real c) complex d) zero

II FILL IN THE BLANKS: (5 x 1 = 5)

11. k . (i + j) = _____

12. In an RCL circuit as $t \to \infty$ the transient component of current tends to _____

13. "Line integral is path independent" – this statement holds good for _____ field.

14. Voltage drop across capacitance is _____

15. The argument of (5-3i) is _____

III ANSWER BRIEFLY (5 x 2 = 10)

16. What is a conservative vector field?

17. Prove that $\overline{A} \cdot (\overline{A} \times \overline{C}) = 0$.

18. Write any two Maxwell's equation with its significance

19. Show that acceleration a = v dv/dx

20. What is boundary value? Give example

SECTION – B

ANSWER ANY FIVE QUESTIONS: (5 x 6 = 30)

21. An electric field is given as $E = 6y^2z\ i + 12xyz\ j + 6xy^2\ k$. An incremental path is given by dl = -3 i + 5 j – 2 k mm. Calculate the work done in moving a 2mC charge along the path if the location of the path is at p(0,2,5) is in Joule.

22. A particle moves along a curve whose parametric equations are $x = 3e^{-2t}$, y = 4 Sin 3t, z = 5 Cos 3t where 't' is the time. Find the magnitudes of the velocity and acceleration at t = 0.

23. Determine the divergence of F = 30 i + 2xy j + 5xz2 k at (1, 1, - 0.2) and state the nature of the field.

….3

24. State Gauss' divergence theorem. b) Use the theorem to solve $\iint$ ⟦A.ds⟧ where A= x^2 i+y^2 j+z^2 k taken over the cube of side one unit.

25. An RL circuit has a resistance of 10 ohms and inductance of 1.5 Henries, an applied emf of 9 volts and an initial current of 6 amps. Find (a) the current in the circuit at any time t and (b) its transient component.

26. A body weighing 64 lb is dropped from a height of 100 ft with an initial velocity of 10 ft/sec. If the limiting velocity is 128 ft/sec, Find expression for velocity and position at any time t.

27. Find the polar form of (1-i) and (1+3i)

SECTION – C

ANSWER ANY THREE QUESTIONS: (3x15=45)

28. a) Prove $\nabla r^n = n\, r^{n-2}\, \mathbf{r}$

b) Calculate the force acting on an electron in a magnetic field of intensity 0.1 tesla directed along Z-axis when the electron has a velocity 10^4 ms^{-1} along X-axis. Find its velocity also.

29. a) Show that $\vec{A} = (2xy + z^3)\vec{i} + x^2\vec{j} + 3xz^2\vec{k}$ is a conservative force field. Find the scalar potential.
b) Find the work done in moving a particle in this field from (1, 2, 3) to (-2, 4,3)

30. a) A particle moves so that its position vector is given by r = (cosωt)i^ + (sinωt)j^ where ω is a constant. Show that (i) v is perpendicular to r (ii) acceleration 'a' is directed towards the origin and has the magnitude to the distance from the origin.
b) If F = $\nabla\Phi$, then show that the work done in moving a particle from $P_1 = (x_1, y_1, z_1)$ in this field to another point $P_2 = (x_2, y_2, z_2)$ is independent of the path joining the point

31. a) Derive Gauss's law in electrostatics in differential form
b) Obtain Laplace and Poisson's equation.

32. a) A spring for which k = 50 Nm^{-1} hangs in a vertical position with its upper end fixed. A mass of 5 kg is attached to the lower end. After coming to rest, the mass is pulled down 0.05m and released. Discuss the resulting motion of the mass, neglecting air-resistance.

b) Explain how polar form of complex numbers is useful in multiplication and division of complex numbers with example

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