

# University of Sargodha

M.A/M.Sc. Part-I/Composite Exam 2<sup>nd</sup> A- 2019 & 1<sup>st</sup> A-2020

Mathematics: IV

Mechanics

Maximum Marks: 100

Time Allowed: 3 Hours

Note: Objective part is compulsory. Attempt any four questions from subjective part.

## Objective Part (Compulsory)

Q.1. Write short answers of the following in 2-3 lines each. (2\*10)

- Define a vector point function.
- Prove that  $\nabla(\ln r) = \frac{\vec{r}}{r^3}$ .
- Explain the term normal derivative.
- Define tangential line integral.
- Define curvilinear coordinates.
- Explain geometrically the coordinates curves in polar coordinates.
- Explain the term contraction of tensors.
- Give few lines about Newtonian and non-Newtonian mechanics.
- Define escape velocity.
- Define angular momentum.

## Subjective Part (4\*20)

- Q.2. (a) Prove that  $\nabla(\vec{A} \cdot \vec{B}) = (\vec{B} \cdot \nabla) \vec{A} + (\vec{A} \cdot \nabla) \vec{B} + \vec{B} \times (\nabla \times \vec{A}) + \vec{A} \times (\nabla \times \vec{B})$   
(b) Evaluate  $\iint_S \vec{A} \cdot \hat{n} dS$ , where  $\vec{A} = y \hat{i} + 2x \hat{j} - z \hat{k}$  and S is surface of the plane  $2x + y = 6$  in the first octant cut off by the plane  $z = 6$ .
- Q.3. (a) State and prove Gauss's divergence theorem.  
(b) Find volume of the region common to the intersecting cylinders  $x^2 + y^2 = 4$  and  $x^2 + z^2 = 4$ .
- Q.4. (a) Derive relations for gradient and divergence in orthogonal curvilinear coordinates.  
(b) Derive relations for unit vectors of spherical coordinates in terms of unit vectors of cartesian coordinates.
- Q.5. (a) Prove that if  $A_i$  are the components of a first order tensor i.e. vector  $\vec{A}$  then  $\frac{\partial A_i}{\partial x_j}$  is a second order tensor. Hence prove that  $\nabla \cdot \vec{A}$  is a scalar quantity.  
(b) Find eigenvalues and eigenvectors of the second order tensor  $\begin{bmatrix} 13 & -3 & 5 \\ 0 & 4 & 0 \\ -15 & 9 & -7 \end{bmatrix}$ .
- Q.6. (a) State and prove Euler's theorem on rigid body kinematics. Also state the Chasle's theorem.  
(b) Prove that for any time-dependent vector function  $\vec{A}$ ,  $\left( \frac{d\vec{A}}{dt} \right)_r = \left( \frac{d\vec{A}}{dt} \right)_f + \omega \times \vec{A}_r$ , where  $\vec{A}_f$  and  $\vec{A}_r$  show the vector in fixed and rotating coordinates axes.
- Q.7. (a) Prove that the two systems S and S' are equimomental if and only if (i) they have the same mass, (ii) they have the same centroid, (iii) they have the same principal axes and same principal moment of inertia at the center of mass.  
(b) Calculate the inertia matrix of a uniform solid rectangular box at one of its corners.

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