Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, July 2020

Course: Advanced Robotics **Semester: VI**
Program: B.Tech Mechatronics **Time : 03 hrs.**
Course Code: MEPD3009 **Max. Marks: 100**

Instructions:

(i) There are total of six questions in this question paper. One in Section A and five in Section B
(ii) Section A will be conducted online on BB Collaborate platform
(iii) Section B consist of long answer based questions and has the total weightage of 75%. The questions for section B shall also appear in BB Collaborate
(iv) The maximum time allocated to Section A is one Hrs.
(v) Section B to be submitted within 24 hrs from the scheduled time.
(vi) The section B should be attempted in blank white sheets (hand written) with all the details like programme, semester, course name, course code, name of the student, Sapid at the top (as in the format) and signature at the bottom (right hand side bottom corner

Section A

1. MCQ **25 Marks**

Q1. Workspace boundary singularities occur when the manipulator is

(a) Fully stretched out
(b) Folded back
(c) Very near the boundary
(d) All of the above

Q2. Workspace interior singularities occur away from the workspace boundary; they generally are caused by a lining up of

(a) Two or more joint axes
(b) Two or more joint axes intersection
(c) Two or more joint axes inclination
(d) Two or more joint axis missing

Q3. When a manipulator is in a singular configuration , it has

(a) Lost one or more degree of freedom
(b) Gain one or more degree of freedom
(c) None

(d) Avoid locking position

Q4. Choose the most geometric problem with Cartesian path

(a)intermediate point unreachable

(b) high joint rates near singularity

(c) start and goal reachable in different solutions

(d) all of the above

Q5. The manipulability measure of redundant manipulator ***w*** is described by

(a) $det(J(\theta)J'(\theta))$
(b) $\sqrt{det(J(\theta)\,J'\,(\theta))}$
(c) $\sqrt[3]{\det(J(\theta)J'(\theta))}$
(d) $\det(J(\theta)$

Q6. The major potential use of redundant robot is in avoid collision while operating in

(a) cluttered work environments
(b) space work environment
(c) limited workspace environments
(d) None

Q7. Closed loop structure of robot offer a benefit

(a) Increased stiffness of the mechanism
(b) Increased workspace of the mechanism
(c) Increased dexterity of the mechanism
(d) None

Q8. The major disadvantage of using gearing are added

(a) Backlash
(b) interference
(c) Oscillation
(d) Nonlinearity

Q9. Cables or flexible bands can be used either in a closed loop or as a single ended elements that are always kept in by sort of preload

(a) Tension
(b) Compression
(c) Shear

(d) Torsion

Q10. An important goal for the design of most manipulators is overall stiffness of the structure and the drive system. Stiff systems provide two main benefits.

(a) do not have sensors to measure the tool frame location directly and flexibilities in the structure or drive train will lead to resonances
(b) compliance and flexibility of link
(c) rigidity of the link and natural frequency of the system
(d) avoid singularity and redundancy

Q11. If the parameters of the manipulator link system are $m = 1, b = 1$ and $k = 1$,find gains k_p and k_v for a position regulation control law that results in the system's being critically damped with a closed stiffness of 16.

(a) 15 & 7
(b) 16 & 8
(c) 20& 10
(d) 22&11

Q12. If the apparent link inertia , I, varies between 2 & 6 kg-m^2 , the rotor inertia is $I_m = 0.01$ kg-m^2 , and the gear ratio is η=30, what are the maximum and the minimum effective inertia of the system.

(a) 15 & 11
(b) 16& 8
(c) 10 & 5
(d) 12& 6

Q13. The practical consideration in developing the decoupling and linearizing control are

(a) Time required to compute the model
(b) Feed forward control system
(c) Dual rate computed torque implementation
(d) Lack of knowledge parameter
(e) None
(f) All of the above

Q14. The drawback of Cartesian based control system is

(a) Perform many computation in the loop
(b) Perform many computation in the outer loop
(c) Perform many computation in the feedback loop
(d) None

Q15. Every manipulation task can be broken down into subtasks that are defined by a particular contact situation occurring between the manipulator end-effector (or tool) and the work environment. With each such subtask, we can associate a set of constraints, called the

(a) natural constraints

(b) artificial constraints

(c)workspace

(d) singularity

Q 16. Degree of freedom of manipulator equals to the

(a) Artificial constraint
(b) Natural constraints
(c) None
(d) Passive joint

Q17.Singularity can be used for the robotic manipulator for the

(a) Locking
(b) Dexterity increase
(c) Stiffness
(d) Redundant

Q18. A sequence of planned artificial constraints that will cause the task to proceed in a desirable manner is called

(a) Assembly strategy
(b) Control strategy
(c) Partitioned strategy
(d) None

Q19. The hybrid position/force controller must solve the problems:

(a) Position control of a manipulator along directions in which a natural force constraint exists.

(b) velocity control of a manipulator along directions in which a natural position constraint exists.

(c) A scheme to implement the arbitrary mixing of these modes along linear degrees of freedom of an arbitrary frame, {C}.

(d) position control

Q20. The benefit of the passive compliance in the robotics system

(a) Mating the parts
(b) Jamming of the object
(c) Increase workspace
(d) More dexterity

Q21. The hybrid control system of the robotic manipulator control the

(a) Position and force
(b) Velocity and acceleration
(c) velocity and torque
(d) change in position

Q22. The sensing allows a manipulator to detect contact with a surface and, using this sensation, to take some action is called

(a) force sensing
(b) position sensing
(c) velocity sensing
(d) acceleration sensing

Q23. The limitation of partitioned proportional derivative control is

(a) not suitable for highly nonlinear system
(b) not suitable for bounded disturbance
(c) not suitable for more degree of freedom manipulator
(d) None

Q24. The control tuning parameter of the adaptive control system is

(a) Self-tune
(b) Depend on the environment
(c) Independent from the environment
(d) Nature of constraint

Q25. The minimum number of degree of freedom required for the redundant manipulator is

(a) 6
(b) 2
(c) 3
(d) 4

Section B

Attempt all the questions

Q2. In Fig.1 two 3R mechanisms are shown. In both cases, the three axes intersect at a point (and, over all configurations, this point remains fixed in space). The mechanism in Fig. (a) has link twists (α_i) of magnitude 90 degrees. The mechanism in Fig.1 (b) has one twist of Φ in magnitude and the other of 180-Φ in magnitude. The mechanism in Fig.1(a) can be seen to be in correspondence with Z—Y—Z Euler angles, and therefore we know that it suffices to orient link 3 (with arrow in figure) arbitrarily with respect to the link 0. Because Φ is not equal to 90 degree, it turns out that the other mechanism cannot orient link 3 arbitrarily. Describe the set of orientations that are unattainable with the second mechanism. Note that we assume that all joints can turn 360 degrees (i.e. no limits) and we assume that the links may pass through each other if need be (i.e., workspace not limited by self-collisions). 15 Marks

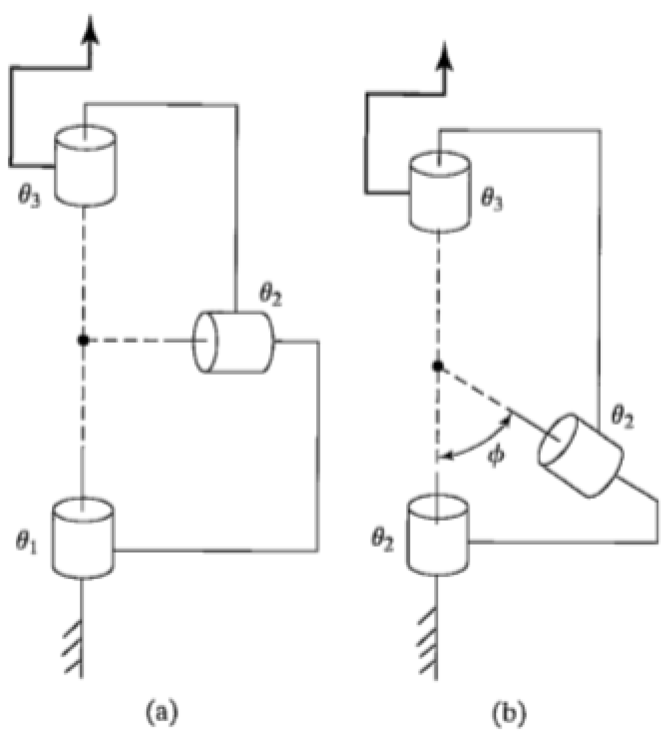

Fig .1

Q3. Write a subroutine that solves quartic equations in closed form. 15 Marks

Q4. A 4R manipulator is shown schematically in Fig. 2. The nonzero link parameters are a_1= 1, α_1 = 45°, d_3= $\sqrt{2}$and a_3= $\sqrt{2}$ and the mechanism is pictured in the configuration corresponding to θ= [0, 90°, —90°, 0] ^{T}. Each joint has ±180° as limits. Find all values of θ_3 such that
${}^{0}_{4ORG}P = [1.1\ \ 1.5\ 1.707]^T$ 15 Marks

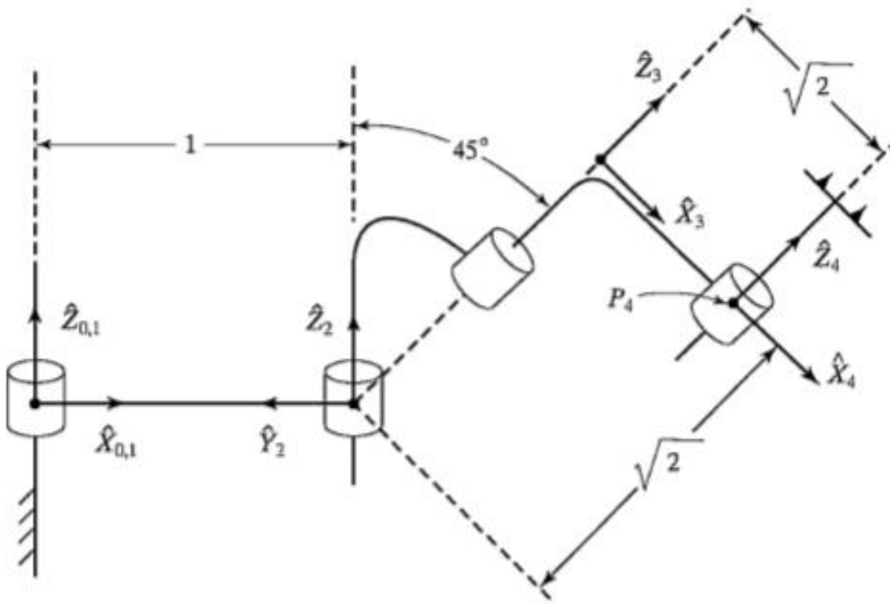

Fig.2

Q5. Write down a general inverse-kinematic solution for the Stewart mechanism shown in Fig. 3. Given the location of {T} relative to the base frame {B), solve for the joint-position variables d_1 through d_6. The are 3 x 1 vectors which locate the base connections of the linear actuators relative to frame {B}. The ${}^{T}_{i}q$ are 3 x 1 vectors, which locate the upper connections of the linear actuators relative to the frame {T}. 15 Marks

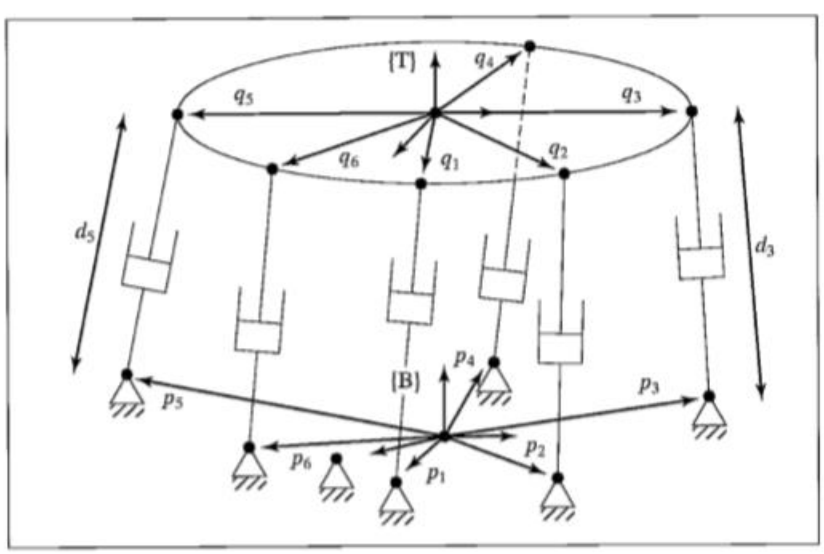

Fig.3

Q6. Draw a block diagram showing a Cartesian-space controller for the two-link arm, such that the arm is critically damped over its entire workspace.