NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

Degree of Master of Engineering

2nd SEMESTER MAIN EXAMINATION

COURSE : AUTOMATION AND ROBOTICS

CODE : TIE 6220

DATE : MAY 2014

DURATION : 3 HOURS

INSTRUCTIONS TO CANDIDATES

1. **Answer FIVE questions.**
2. **Each question carries 20 marks and the marks allocated to sub-sections of whole questions are indicated on the right hand margin against the sub-section.**
3. **This paper contains seven (7) questions**
4. **There are five (5) printed papers**

Question 1

(a) A wire-wound potentiometer is to be used to measure angular position. A 100-turn (i.e. 100 loops) resistive element is used and the wiper can rotate 300°, 10V dc is supplied to the pot. Determine the resolution of the device [2]

(b) With the aid of diagrams describe the principle of operation of Rotary absolute encoders. [4]

(c) Besides monitoring the position and velocity of a physical system, it is also possible to monitor its acceleration. Show how accelerometers enable robots to achieve this. [4]

(d) Describe the principle of operation of a Remote Centre Compliant. [4]

(e) Given that Figure Q1 shows a peg in a hole. If β is assumed to be very small show that the limit for wedging is $$\theta \leq \frac{R-r}{R\mu}$$ [6]

Where $\mu = \tan\theta$

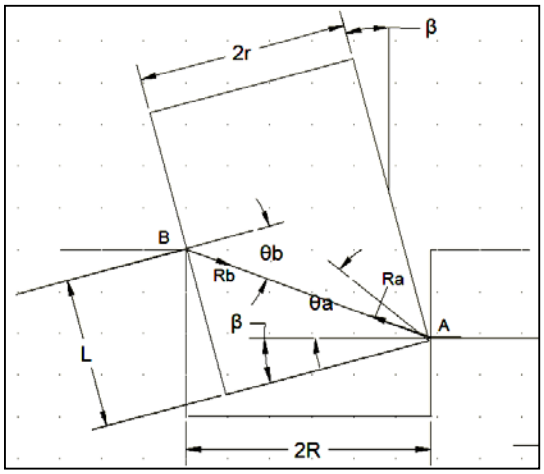

Figure Q1 Limiting case for wedging

Question 2

(a) Discuss the operation of three fibre optic sensors that you know, giving examples of their application [7]

(b) Show, by using a real life factory based example, why one would prefer having tactile sensors compared to optical sensors on a robot wrist. [4]

(c) How do the following design for assembly (DFA) practices aid robotic assembly

(i) Number of product parts should be kept at a minimum [3]

(ii) All parts should be inserted using a straight-line motion from an above position. [3]

(iii) The use of coil springs, returning rings, keys and keyways that require special insertion tools should be avoided. [3]

Question 3

(a) Assume you have available a RAM of size 16,384 8-bit bytes. Organize a storage allocation map for this RAM so that you can store images from 32x32 to 1024x1024 pixels. Discuss in detail the specific size of the pixel maps, with regards to x and y and gray level [4]

(b) Discuss three types of reflective illumination giving areas of application. [6]

(c) Your company installs a new automatic feeding device to the plant and do not modify the design of the parts. Production decreases due to too many plant stoppages.

(i) What are the three main causes of problems that can result in these stoppages? [3]

(ii) How do you resolve the problem in (i)? [5]

(d) Why would you prefer a modular design in robotic assembly? [2]

Question 4

Figure Q4 shows a plan view of a two-joint articulated arm operating close to a conveyor. The arm is initially adjusted so that the first joint takes an angle $\theta_1 = \frac{\pi}{4}$ and the second joint an angle $\theta_2(t=0) = \frac{\pi}{2}$. Joint one then remains in this position whilst joint two can be considered to perfectly follow a ramp command:

$$\theta_2 = \theta_2(t=0) - \alpha t .$$

Simultaneously the component on the conveyor moves from a start position x_0, y_0, perfectly following a further ramp command:

$$y = y_0 - \beta t .$$

Assuming that the component on the conveyor and the end-effector on the outer end of link 2 can both be considered as points, determine, using homogeneous transforms whether the two will collide. You may neglect any collision between arm and component – examine only the end-effector and component.

[20]

Data
$\alpha = 0.3927$ rads^{-1}
$\beta = 0.3885$ ms^{-1}
$x_0 = 2.0$ m
$y_0 = 1.8385$ m
$\ell_1 = 1.5$ m
$\ell_2 = 1.016$ m

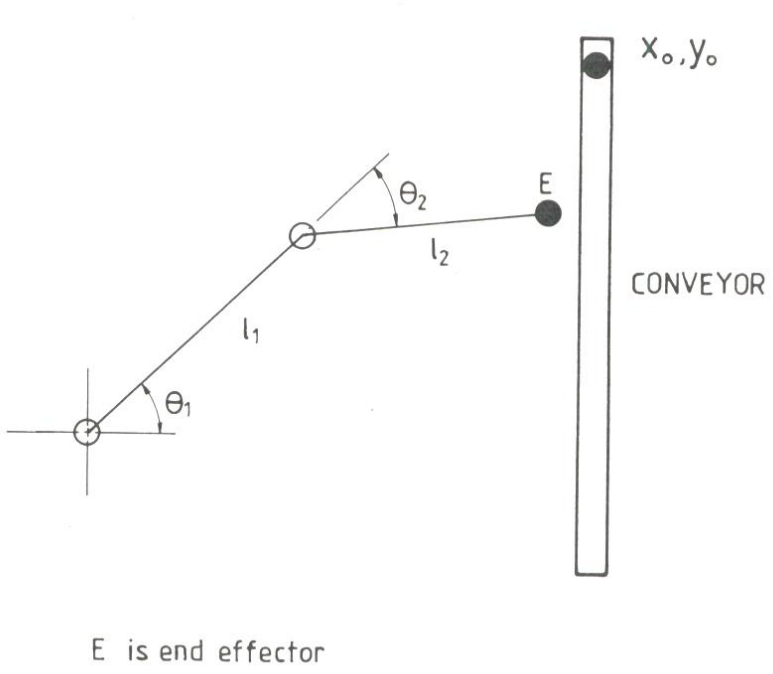

Fig Q4 Plan view of 2 joint articulated arm

Question 5

(a) Discuss the concept 'Degrees of Freedom (DOF) in relation to the design of industrial robots. The answer should include reference to: sources of DOF, reasons for more than six apparent DOFs and the number of DOF required for different tasks. [10]

(b) A robot joint having a single rotational DOF is to be controlled by a model-based controller. Friction in the joint follows a Coulomb law and a mass attached to the arm causes gravitational torque to be applied to the joint. Describe fully a control system suitable for a step input command, including in your description a block diagram of the controller. What requirement applies to ensure critical damping? [10]

Question 6

(a) Name any three types of actuators that are used as robotic drives [3]

(b) With the aid of diagrams describe the mode of operation of each giving the areas of application where each is preferred. [9]

(d) Define the following terms as understood in robotics:

(i) Accuracy [2]

(ii) resolution [2]
(iii) repeatability [2]
(iv) steady-state [2]

Question 7

(a). Draw neat and annotated sketches of the following types of robot joint configurations:

(i) Rectangular [4]
(ii) Cylindrical [4]
(iii) Spherical [4]
(iv) Articulated (Revolute) [4]

Indicate the directions of movement about and along the axes and the number of degrees of freedom in each case.

(b) What does the term SCARA stand for? Suggest two cases/applications where this type of robot can be used. [4]

END OF EXAMINATION