EE540 Tutorial 1

2002/03 Examination
Question 1

Question 1   Motion System Structures

A high-speed pick-and-place machine needs to pick-up delicate objects from one location, and place them onto another location, as shown in figure Q1. Since the object is soft and delicate, its shape and size may vary from sample to sample. The mechanism is to be controlled by a multi-axis controller, under mixed-mode operation.
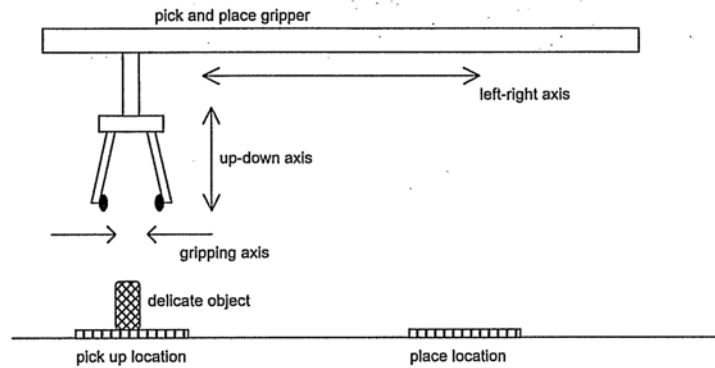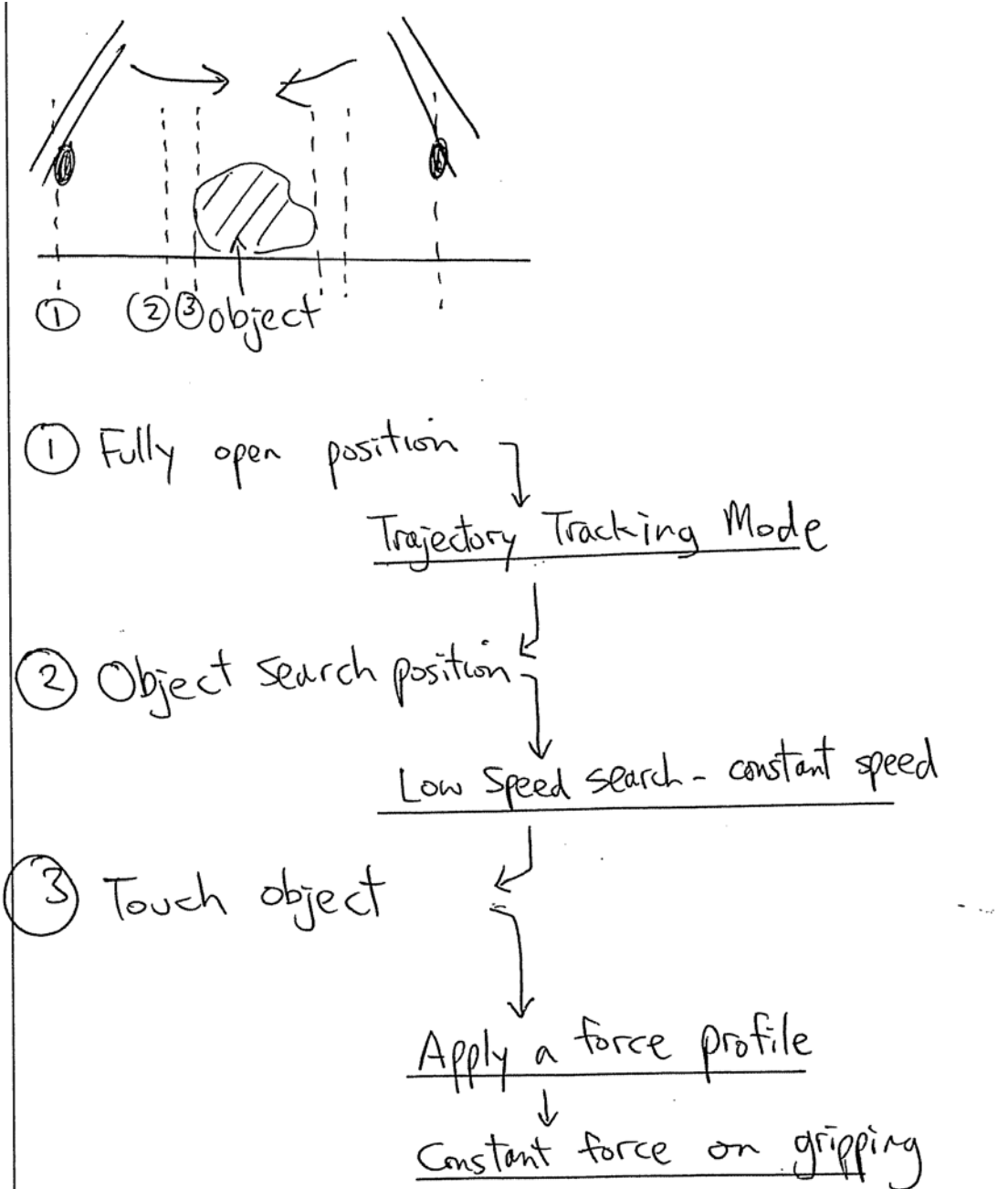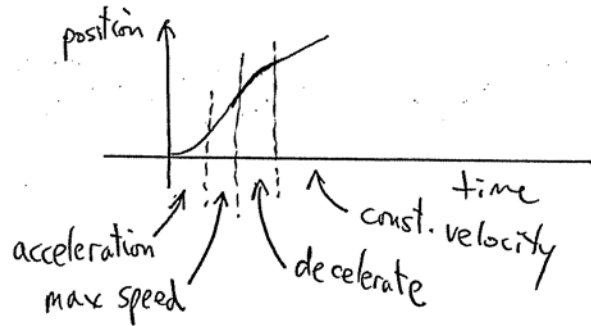

Figure Q1

(a)   For the gripping axis, list the number of operation modes the gripper has to go through, before it actually grips firmly on the object. The gripping action must be done at the highest possible speed. For each of the motion mode, what are the conditions for switching from one mode to another?   (10 marks)

(b)   List the motion sensor requirements of (a), and describe where are they located.   (5 marks)

(c)   Design the motion profiles of the up-down axis and the left-right axis, so that the delicate object can be transferred from one location to another in the shortest possible time. Draw the motion profiles (i.e. position and velocity versus time) of these two axes.   (10 marks)
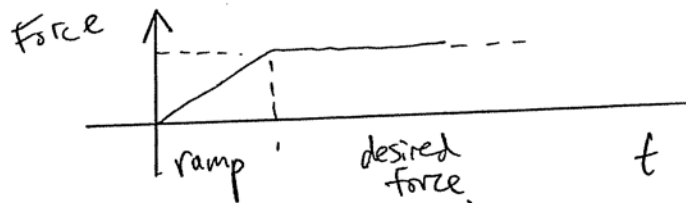
Solution 1a

① Fully open position
→ Trajectory Tracking Mode

② Object search position
→ Low Speed Search - constant speed

③ Touch object
→ Apply a force profile
→ Constant force on gripping

<u>Trajectory Tracking Mode</u> : Apply constant acceleration
until it reaches desired speed. Decelerate to
search speed just before it reaches point 2

position ↑

acceleration

max speed

decelerate

const. velocity

time

<u>Object speed search</u> : Constant velocity control
until it hits the target.

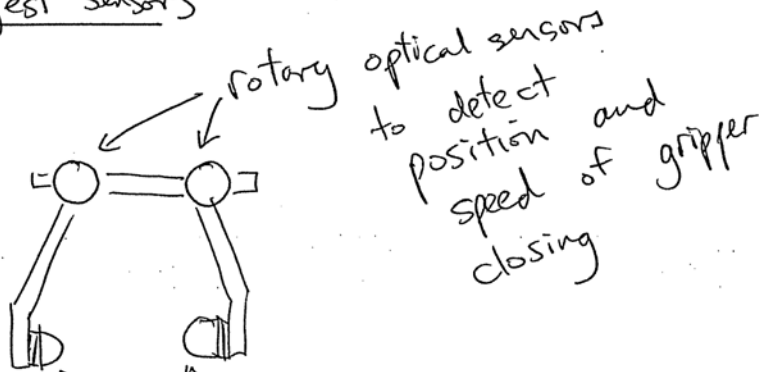<u>Force control</u> : Apply a force ramp until
it reaches the desired level

Force ↑

ramp

desired
force

t

<u>Conditions for switching</u>

at ① ------ start command from user

at ② ------ the desired position is reached

at ③ ----- object detected by force sensor

Solution 1b

Suggest Sensors

rotary optical sensors
to detect
position and
speed of gripper
closing

tactile sensor
finger tips
to provide
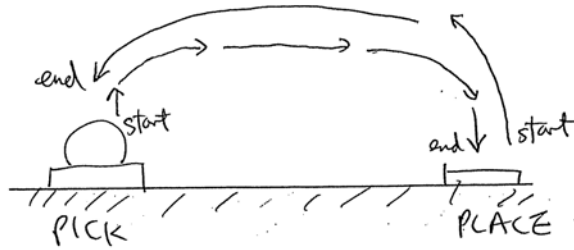feed back on force

Specifications

Rotary Sensor ——— resolution * 10-20 times
better than the
gripper position
resolution
* must also produce
adequate resolution
for slow speed search.

speed * 10~20 times
better than the
highest mechanical
resonant.

Tactile sensor ——— * minimum hysteresis
* resolution 10-20 times
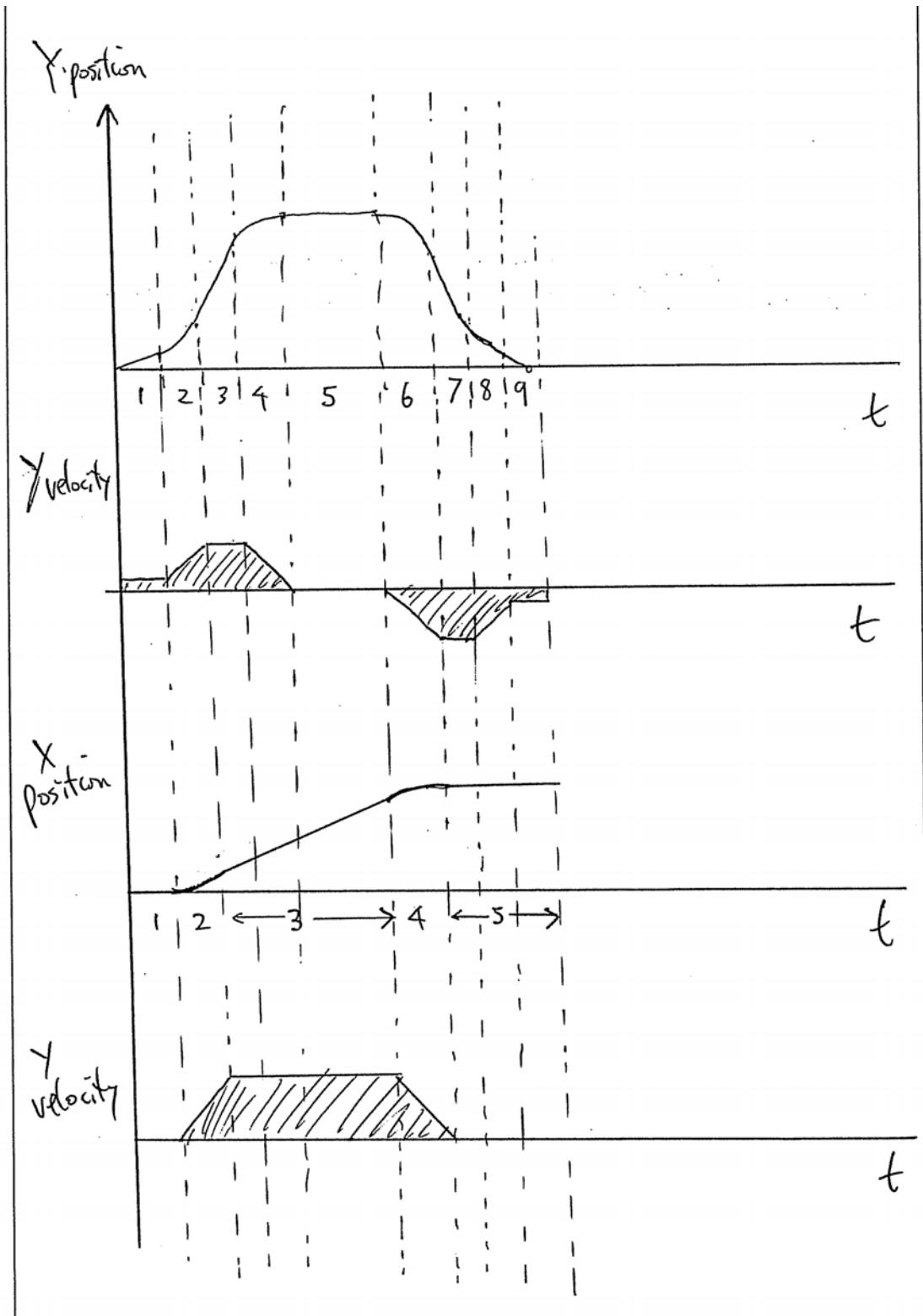better than the gripper
force spec.

Solution 1c

Design criteria
1. Pick and place locations must be very accurate
2. The machine must be stitionary when gripping or releasing the object.
3. The travelling path is unimportant, as long as the object does not touch the ground.

	X motion		Y motion	explanation
1.	low velocity Constant speed ↑	1	stop	Y moves up to clear plane
2	Constant acceleration ↑	2	Constant acceleration →	↑ Y moves up in min time
3	Constant max velocity ↑	3	Constant velocity	as soon as Y clears plane, X moves at max speed/ acceleration
4	constant deceleration ↑		→	
5	Stop			↓
6	constant acceleration ↓	4	Constant deceleration →	Y moves down in minimum time
7	constant velocity max ↓			
8	constant deceleration ↓		STOP	↓
9	Constant low velocity ↓			Y moves down until place is reached
10	STOP	4		

1, 02-03

END