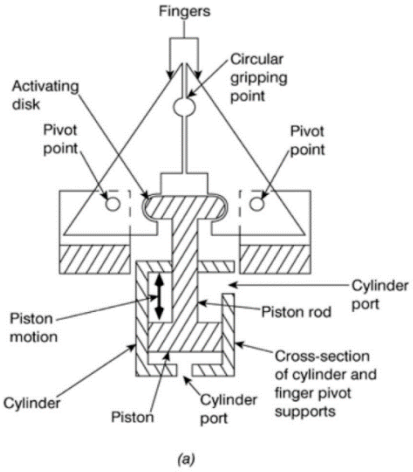
20MECH5131/6031 Intro to Robotics

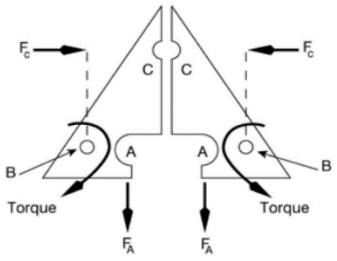
Homework #6, End Effectors (90 pts total)

Student Name: Hongui Yi **Score:** _____

Solve the following problems or briefly answer questions.

Prob.1. (15 pts)





(a) $D = 2in \quad R = 1in$

$2F_a = P \cdot A = 35 \frac{lbf}{in} \times (\pi \times (1in)^2) = 109.96\,lbf$

(b) $F_a \cdot 1in = F_c = 2in$

$F_c = \frac{1}{2} F_a = \frac{1}{2} \times \frac{109.96\,lbf}{2} = 27.49\,lbf$

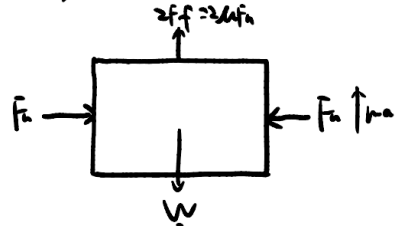
(c) $2F_f = 2\mu F_c$

$+\uparrow \Sigma F: 2F_f - W - ma = 0$

$\Rightarrow a = \frac{2\mu F_c - W}{m} = 38.61\,ft/s^2$

Prob.2. (10 pts)

(a) $W = 20lbs \quad a = 3ft/s^2 \quad \mu = 0.65 \quad m = \frac{W}{g} = \frac{20lbs}{32.2} = 0.621\,slug$

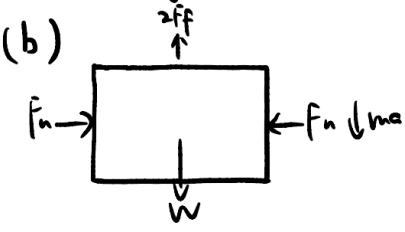


$+\uparrow \Sigma F: 2F_f - W = ma$

$\Rightarrow F_f = \frac{1}{2}(W + ma) = \frac{1}{2}(20 + 0.621 \times 3) = 10.9315\,lbf$

$F_n = \frac{F_f}{\mu_s} = \frac{10.9315\,lbf}{0.65} = 16.82\,lbf$

(b)



$+\Sigma F: 2F_f - W = -ma$

$\Rightarrow F_f = \frac{1}{2}(W - ma) = \frac{1}{2}(20 - 0.621 \times 3) = 8.4685\,lbf$

$F_n = \frac{F_f}{\mu_s} = \frac{8.4685\,lbf}{0.65} = 12.99\,lbf$

Prob. 3. (10 pts)

$P = 0.75 \times 14.7\ psi = 11.025\ psi$

$F = 4PA = 4 \times 11.025\ psi \times \frac{\pi}{4} D^2 = 30\ lbs$

$\Rightarrow D = \sqrt{\frac{30}{11.025\pi}} = 0.93\ in$

Prob. 4. (20 pts)

Last name: Yi, machine time: 9.0 sec

Single gripper design

Cycle time: $T_c = 9 + 2.6 + 1.7 + 1.1 + 0.8 + 1.7 + 0.3 = 17.2$ sec

Production ratio $= \frac{1}{T_c} = \frac{1}{17.2\ sec} \times 60 \frac{sec}{min} \times 60 \frac{min}{hr} \times 8 \frac{hr}{shift} \times 0.8 = 1339 \frac{unit}{shift}$

Dual gripper design

Cycle time

If machine busy: $T_c = 9 + 0.8 + 1.1 = 10.9$ sec

If robot busy: $T_c = 0.8 + 1.7 + 0.3 + 2.6 + 1.7 + 1.1 = 8.2$ sec

$10.9 > 8.2$ So cycle time is 10.9 sec.

Production ratio: $\frac{1}{T_c} = \frac{1}{10.9sec} \times 60 \times 60 \times 8 \times 0.8 = 2113 \frac{unit}{shift}$

Production rate improvement

$\frac{2113 - 1339}{1339} \times 100\% = 57.8\%$

Prob.5. (8 pts)

In the field of fruit collection, pneumatic finger pliers or soft finger pliers can be used. For example, a robot with soft finger grippers can lift an apple from a basket to a box without crushing it. This is because the pneumatic finger gripper can be used for any geometric shape of the object because it is soft. In addition, its force is controlled by pressure, so it is gentle and does not damage the object.

Prob. 6. (27 pts)

a) (9 pts)

Criteria I: Environment protection. The robot and gripper work in a foundry where the environment is relatively unclean. Therefore, the protection of the gripper should be considered.
Criteria II: Cycle time. In order to have high productivity, the cycle time of the gripper is important.
Criteria III: Object shape. For better operation, the gripper should be able to move the object tightly. Therefore, a suitable gripper should match the shape of the object.

b) (9 pts)

Type I: Vacuum gripper: VGC10
Type II: Soft gripper: SG-a-S
Type II: Mechanical gripper: RG6

Table 1: Three Types of Grippers

	Type I	**Type II**	**Type III**
Manufacturers	Onrobot	Onrobot	Onrobot
Model	VGC10	SG-a-S	RG6
Gripper Type	Vacuum	Soft	Mechanical
Description	A compact, customizable electrical vacuum gripper	A flexible food-grade robot gripper	A flexible two finger robot gripper with wide stroke

c) (9 pts)
I recommend Type I: Onboard VGC10. A weighted rating matrix is shown below:

Table 2: Weighted Matrix

		VGC10		**SG-a-S**		**RG6**	
Criteria	Importance Weight	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Protection due to environmental issues	0.3	4	1.2	4	1.2	3	0.9
Adaptation to object shape	0.3	4	1.2	2	0.6	2	0.6
Speed	0.1	3	0.3	1	0.1	3	0.3
Payload	0.1	4	0.4	2	0.2	3	0.3
Work Range	0.1	4	0.4	2	0.2	2	0.2
Accuracy	0.1	2	0.2	4	0.4	4	0.4
Sum	1	21	3.7	15	2.7	17	2.7

The major specifications are listed below:

1. Datasheet

1.1. VGC10

General Properties		Minimum	Typical	Maximum	Unit
Vacuum		5 % -0.05 1.5	- - -	80 % -0.810 24	[Vacuum] [Bar] [inHg]
Air flow		0	-	12	[L/min]
Payload	With default attachments	- -	- -	6 * 13.2 *	[kg] [lb]
	With customized attachments	- -	10 20	15 33.1	[kg] [lb]
Vacuum cups		1	-	7	[pcs.]
Gripping time		-	0.35	-	[s]
Releasing time		-	0.20	-	[s]
Vacuum pump		Integrated, electric BLDC			
Dust filters		Integrated 50µm, field replaceable			
IP Classification		IP54			
Dimensions		101 x 100 x 100 3.97 x 3.94 x 3.94			[mm] [inch]
Weight		0.814 1.79			[kg] [lb]

Reference

[1] https://onrobot.com/us/products/vgc10
[2] https://onrobot.com/us/products/soft-gripper
[3] https://onrobot.com/us/products/rg6-gripper