Chapter 25 #7

Chapter 26 #4 part a only

CH 25

Q7

> You are choosing a motor for the last joint of a new direct-drive robot arm design. (A direct-drive robot does not use gearheads on the motors, creating high speeds with low friction.) Since it is the last joint of the robot, and it has to be carried by all the other joints, you want it to be as light as possible. From the line of motors you are considering from your favorite motor manufacturer, you know that the mass increases with the motor's power rating. Therefore you are looking for the lowest power motor that works for your specifications. Your specifications are that the motor should have a stall torque of at least 0.1 Nm, should be able to rotate at least 5 revolutions per second when providing 0.01 Nm, and the motor should be able to operate continuously while providing 0.02 Nm. Which motor do you choose from Table 25.1? Give a justification for your answer.

We have 4 motors, with poser 3, 10 , 20 ,90

stall torque 0.1Nm: all motors but motor 3 could satisfy this requirement.

With the 0.02Nm normal work load requirement, motor 3 is eliminated as its max continuous torque is only 0.002Nm

Using the torque-speed relationship, we could have this equation

$$\tau = \tau_{stall} * (1 - \frac{\omega}{\omega_{max}})$$

We simply need to plug in the values to find out how much torque each motor can do at 300 rpm

motor	10	20	90
ω_{max} (rpm)	4980	9660	7180
τ_{max} (mNm)	131	225	929
τ (mNm) at 300 rpm	123	218	890

From the table we can tell that all three motor: 10, 20, 90 meets our need. Since we want the smallest motor, motor 10 is enough for us.

ch 26

4

> You are working for a startup robotics company designing a small differential-drive mobile robot, and your job is to choose the motors and gearing. A diff-drive robot has two wheels, each driven directly by its own motor, as well as a caster wheel or two for balance. Your design specifications say that the robot should be capable of continuously climbing a 20 ∘ slope at 20 cm/s. To simplify the problem, assume that the mass of the whole robot, including motor amplifiers, motors, and gearing, will be 2 kg, regardless of the motors and gearing you choose. Further assume that the robot must overcome a viscous damping force of (10 Ns/m)×v when it moves forward at a constant velocity v, regardless of the slope. The radius of the wheels has already been chosen to be 4 cm, and you can assume they never slip. If you need to make other assumptions to complete the problem, clearly state them. You will choose among the 15 V motors in Table 25.1, as well as gearheads with G = 1, 10, 20, 50, or 100. Assume the gearing efficiency for G = 1 is 100%, and for the others, 75%. (Do not combine gearheads! You get to use only one.)

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> Provide a list of all combinations of motor and gearhead that satisfy the specifications, and explain your reasoning. (There are 20 possible combinations: four motors and five gearheads.) "Satisfy the specifications" means that the motor and gearhead can provide at least what is required by the specifications. Remember that each motor only needs to provide half of the total force needed, since there are two wheels.

requirement: * 20 cm/s on 20 deg slop * 2 kg overall load

To overcome gravity, the wheel need to provide a constant forward force of

$$sin(20) * 2kg * 9.8 = 6.703N$$

- wheel radius of 4cm

wheel circumference is 25.14 cm This result in a rotation velocity of

$$\frac{20cm/s}{25.14cm/rev} = 0.7955rev/s$$

or 47.97 rpm

- overcome friction of 10 Ns/m * V

at speed of 20cm/s, the force to overcome the damping force is

$$10Ns/m * 0.2m/s = 2N$$

- each wheel provide half of the force.

Total forward force is $2N + 6.703N = 8.703N$ then distributed to each wheel, each wheel need to provide 4.3515N of linear force. With 4cm wheel radius. The torque needed is $4.3515 * 0.04 = 0.17406Nm$

With the help of python code, I can find all the torque each motor and gearhead combination can provide at required speed.

See `MotorTorqueFinder.py` for the code

motor name	gear ratio	output_torque	meets requirement?
motor 3	1	0.009964201492537314	False
motor 3	10	0.07231511194029852	False
motor 3	20	0.13926044776119406	False
motor 3	50	0.3078777985074627	True
motor 3	100	0.48151119402985076	True
motor 10	1	0.12973813855421687	False
motor 10	10	0.8878603915662651	True
motor 10	20	1.5864415662650604	True
motor 10	50	2.5465097891566266	True
motor 10	100	0.36103915662650576	True
motor 20	1	0.22388268633540373	True
motor 20	10	1.6037014751552796	True
motor 20	20	3.039805900621118	True
motor 20	50	6.3425368788819885	True
motor 20	100	8.49514751552795	True
motor 90	1	0.9227932966573817	True
motor 90	10	6.501997249303622	True
motor 90	20	12.072988997214487	True
motor 90	50	23.19993123259053	True
motor 90	100	23.12472493036212	True

It is obvious in the output, only 4 combinations can't meet the requirement, and other 16 combinations work.