



Benha University

Mechanical Engineering Department (Production)



Shoubra Faculty of Engineering

4th year (Design section) 2016/2017

Assignment (1)

1. In the past, control systems used a human operator as part of a closed-loop control system. Sketch the block diagram of the valve control system shown in Figure (1).

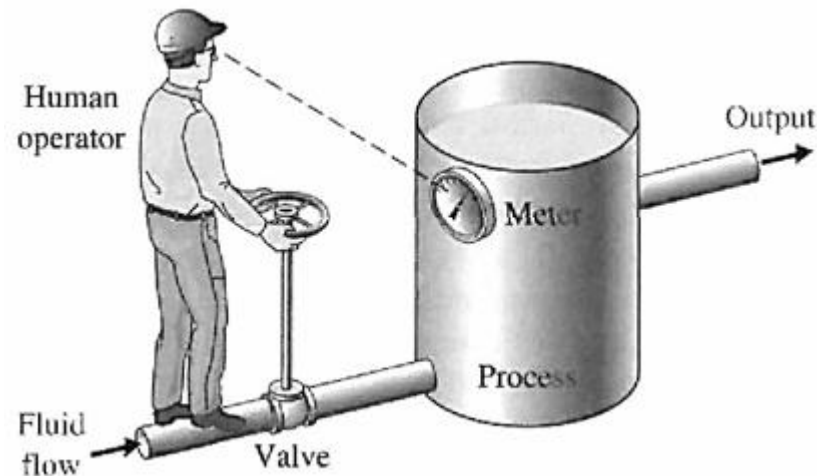


Fig. 1. Flow control valve

2. NASA is developing a compact rover designed to transmit data from the surface of an asteroid back to Earth, as illustrated in Figure (2). The rover will use a camera to take panoramic shots of the asteroid surface. The rover can position itself so that the camera can be pointed straight down at the surface or straight up at the sky. Sketch a block diagram illustrating how the microrover can be positioned to point the camera in the desired direction. Assume that the pointing commands are relayed from the Earth to the microrover and that the position of the camera is measured and relayed back to Earth.



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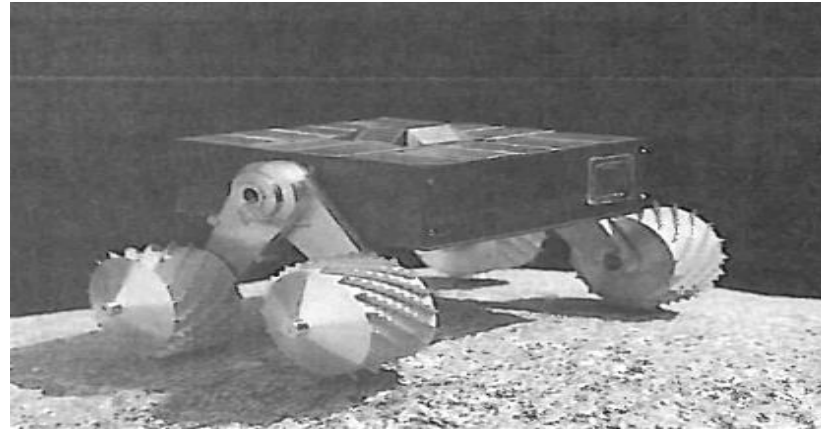


Fig. 2. Micro rover designed to explore an asteroid. (Photo courtesy of NASA.)



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3. Consider the human transportation vehicle (HTV) depicted in Figure (3). The self-balancing HTV is actively controlled to allow safe and easy transportation of a single person. Sketch a block diagram for model, describe a closed-loop feedback control system to assist the rider of the HTV in balancing and maneuvering the vehicle.



Fig. 3. Personal transportation vehicle.
(Photo courtesy of newscom.com.)

4. A cart of mass $m = 1000$ kg is attached to a truck using a spring of stiffness $k = 20,000$ N/m and a damper of constant $c = 200$ Ns/m, as shown in Figure (4). The truck moves at a constant acceleration of $a = 0.7$ m/s².

Write equation of motion between the speed of the truck and the speed of the cart is:

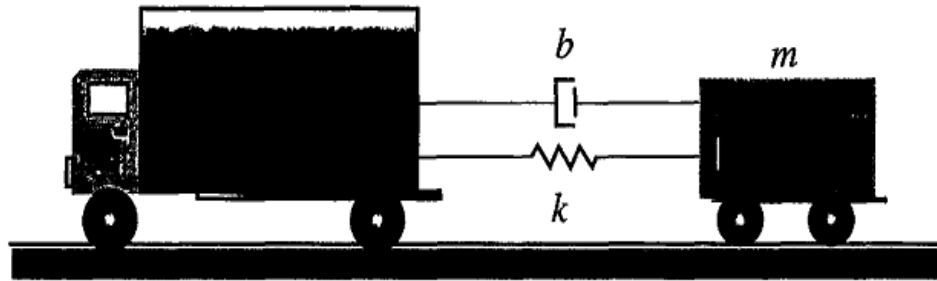


Fig. 4. Truck pulling a cart of mass m

5. A load added to a truck results in a force F on the support spring, and the tire flexes as shown in Figure (5a). The model for the tire movement is shown in Figure (5b). Write equation of motion.

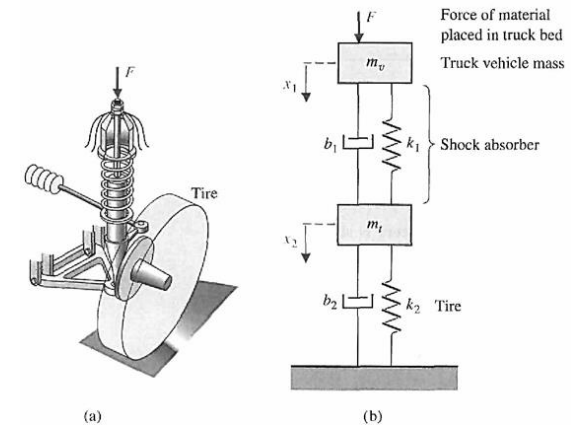


Fig. 5. Truck support model.



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6. A hydraulic servomechanism with mechanical feedback is shown in Figure (6). The power piston has an area equal to A . When the valve is moved a small amount Δz , the oil will flow through to the cylinder at a rate $p^* \Delta z$, where p is the port coefficient. The input oil pressure is assumed to be constant. From the geometry, we find that $\Delta z = k \frac{l_1 - l_2}{l_1} (x - y) - \frac{l_2}{l_1} y$. Determine the closed-loop signal-flow graph or block diagram for this mechanical system, (b) Obtain the closed-loop transfer function $Y(s)/X(s)$.

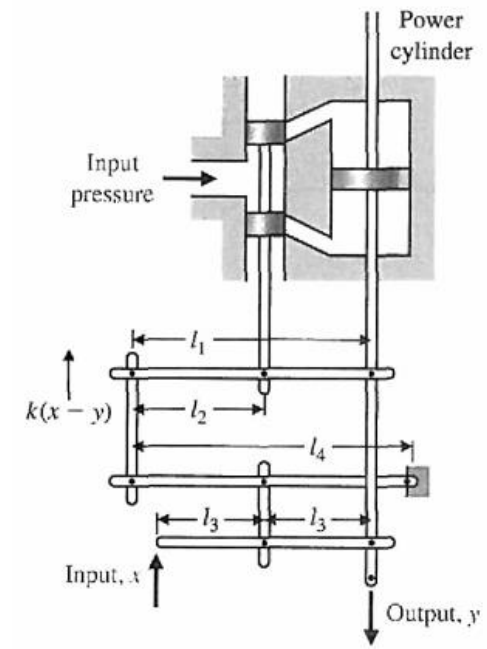


Fig. 6. A hydraulic servomechanism.



7. A position control system is illustrated in Figure 3. Evaluate the transfer function of each subsystem and determine the closed-loop transfer function $\theta_o(s) = \theta_i(s)$.

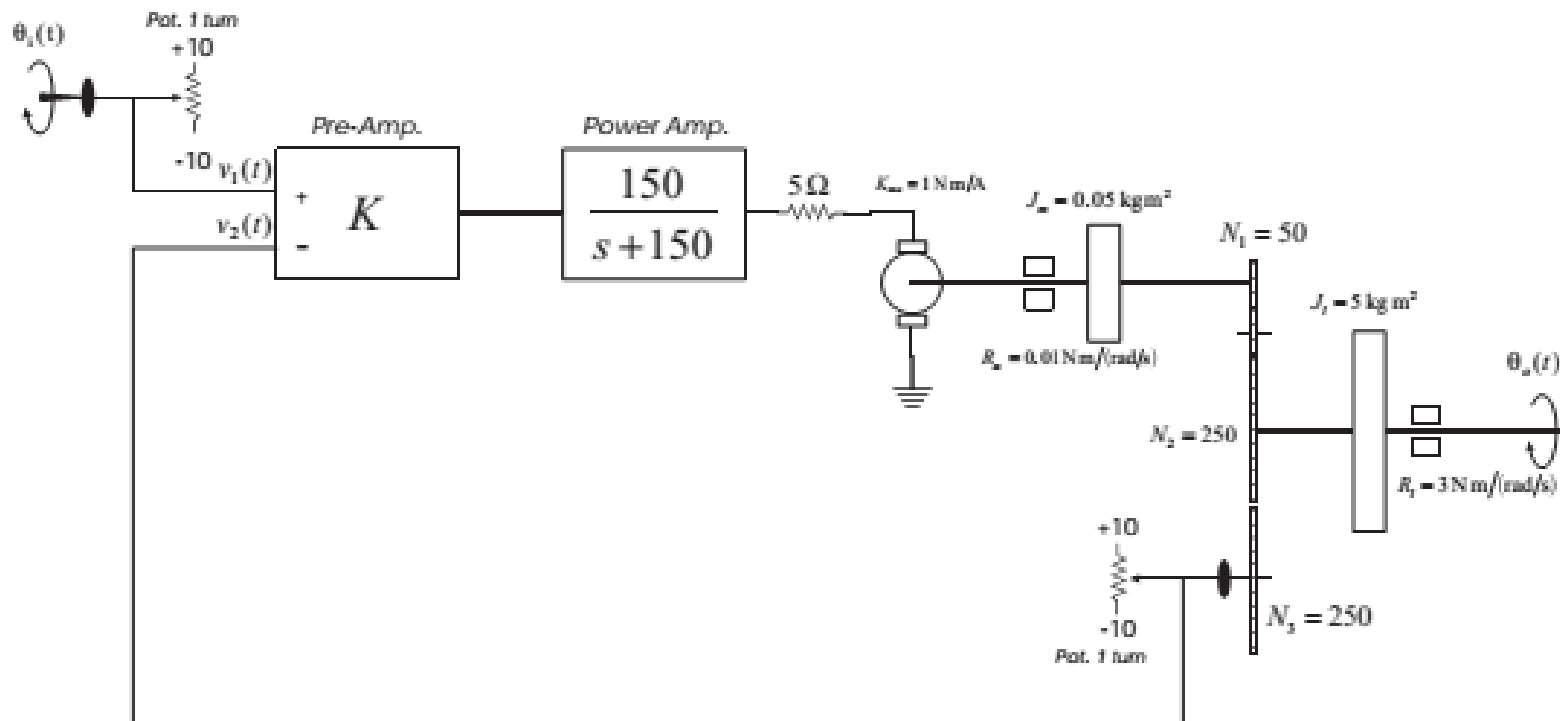


Fig. 7. Position control system.



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8. . In this system shown in figure (8), a tank having liquid capacitance $A1$ is supplying liquid through a pipe of resistance $R1$ to another tank of liquid capacitance $A2$, which delivers this liquid through a pipe of resistance $R2$.
- Write down the system equations in time domain.
 - Draw the block diagram of system.
 - Obtain overall transfer function of the system Q_{out}/Q_{in} using reduction technique.

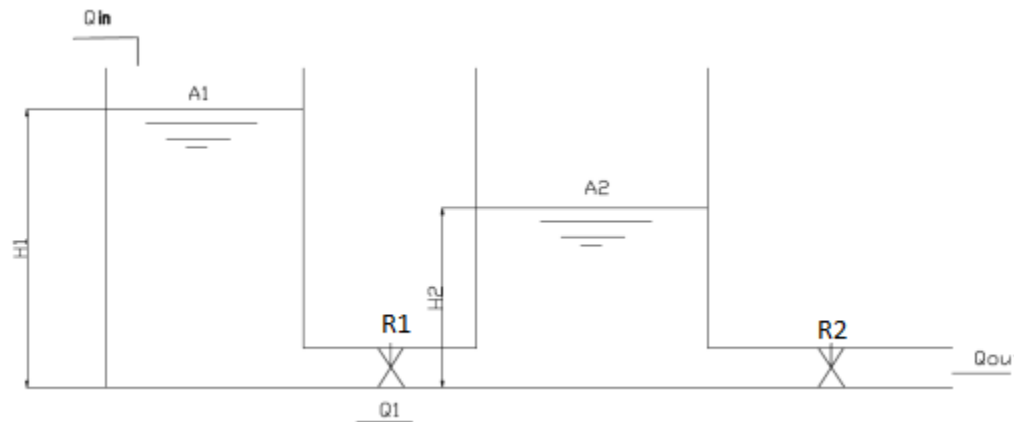


Figure 8: Two tanks connected in series