Chapter 2

Modeling in the Frequency Domain

Figure 2.1
a. Block diagram representation of a system;
b. block diagram representation of an interconnection of subsystems

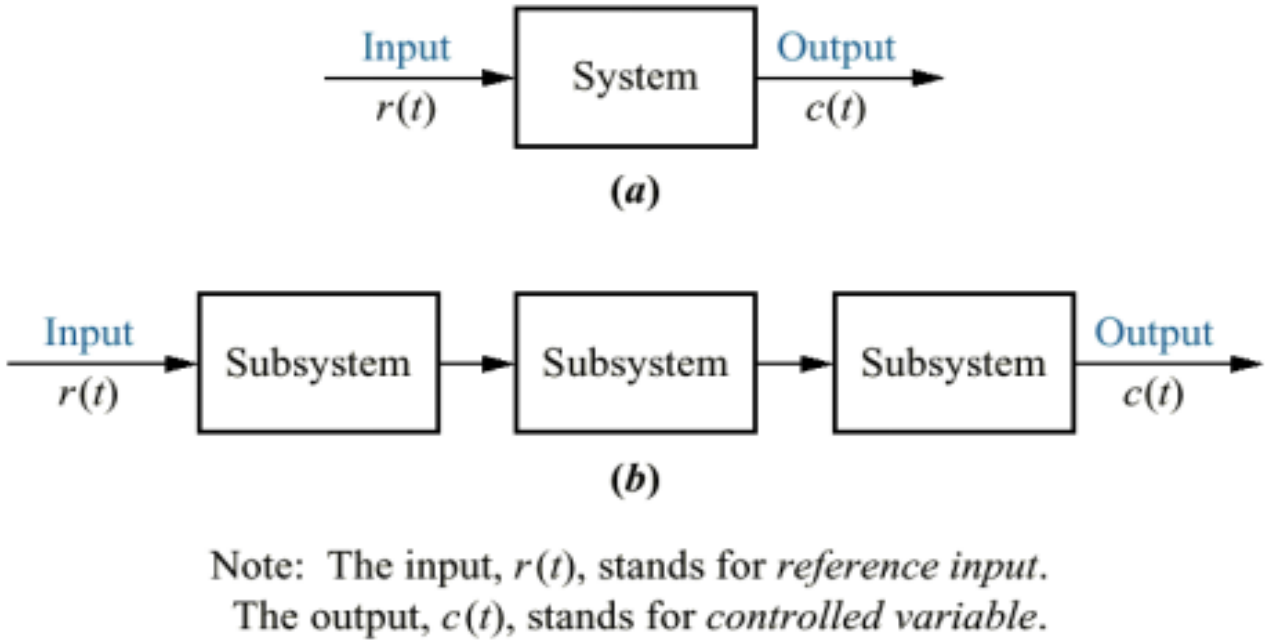


Figure 2.2
Block diagram of a transfer function

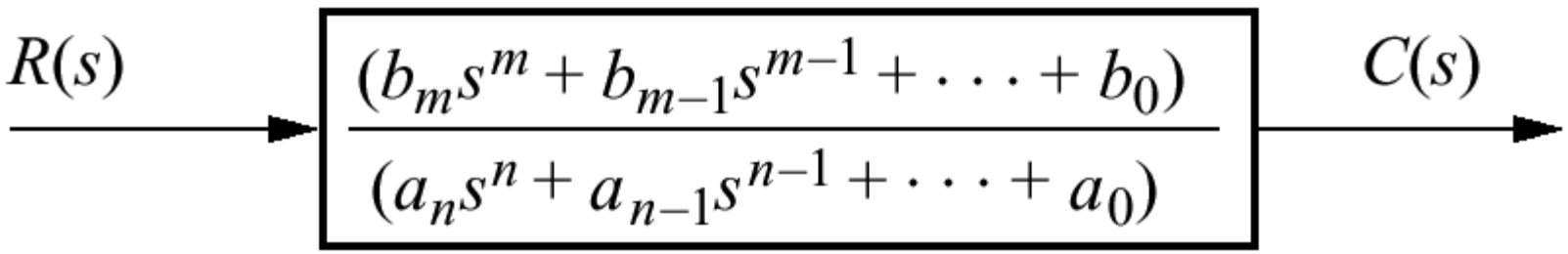


Figure 2.3
RLC network

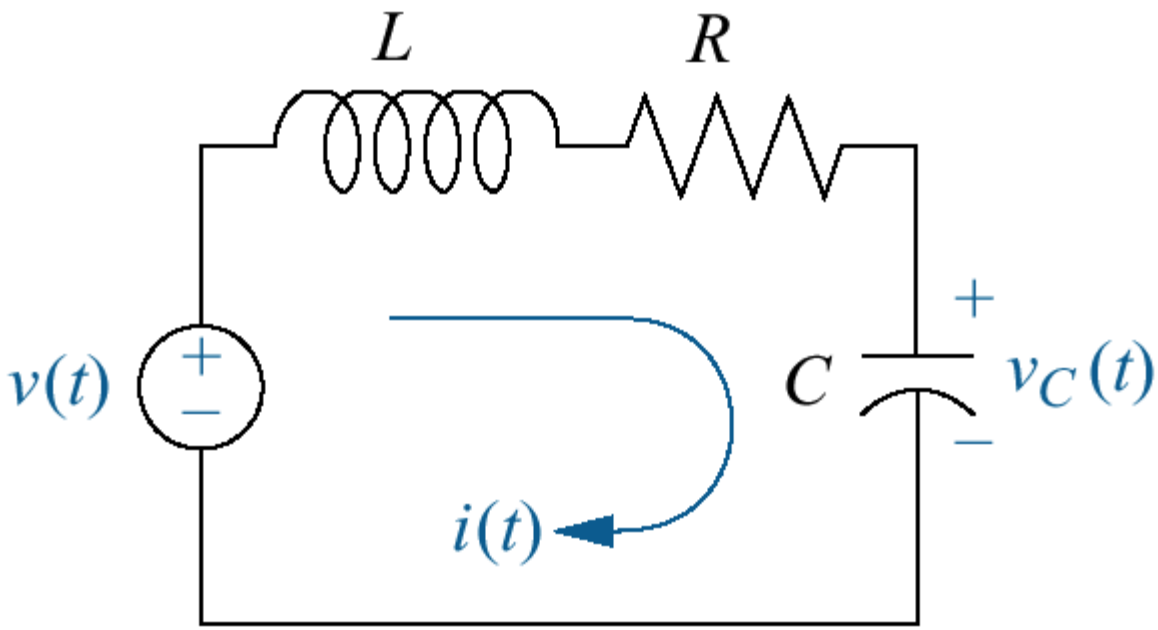


Figure 2.4
Block diagram of series RLC electrical network

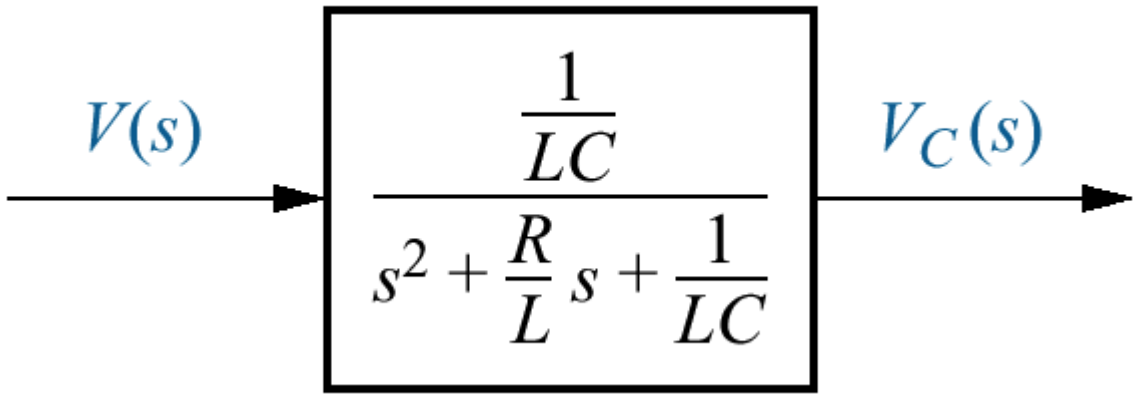


Figure 2.5
Laplace-transformed network

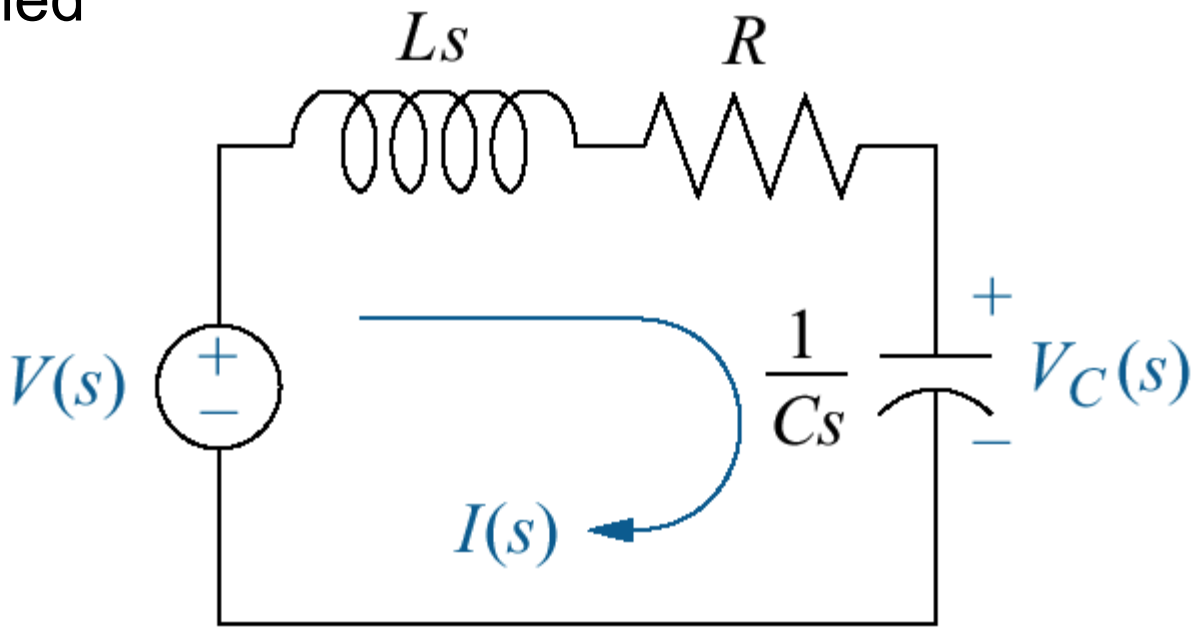


Figure 2.6
a. Two-loop electrical network;
b. transformed two-loop electrical network;
c. block diagram

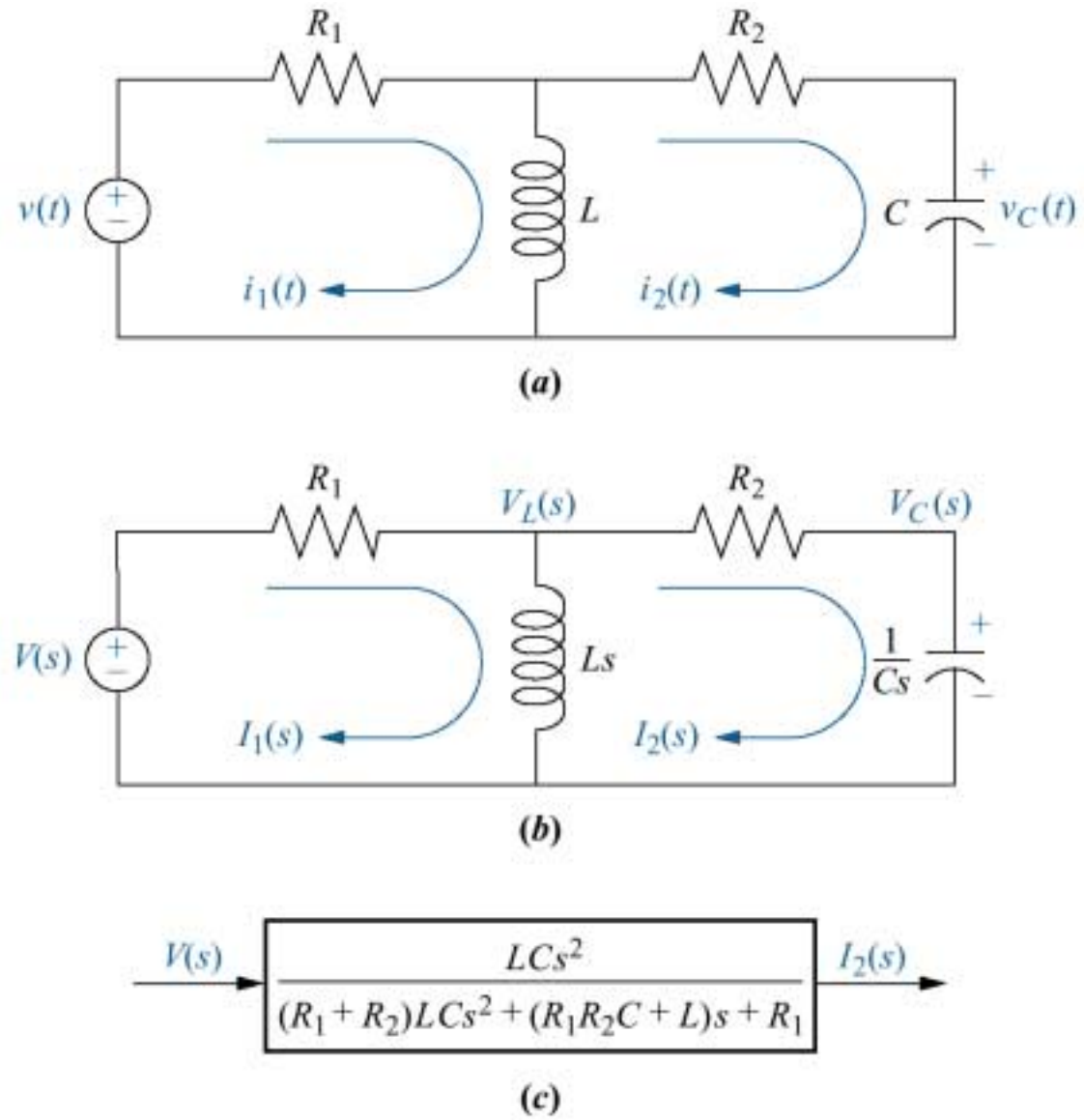


Figure 2.7
Block diagram of the network of Figure 2.6

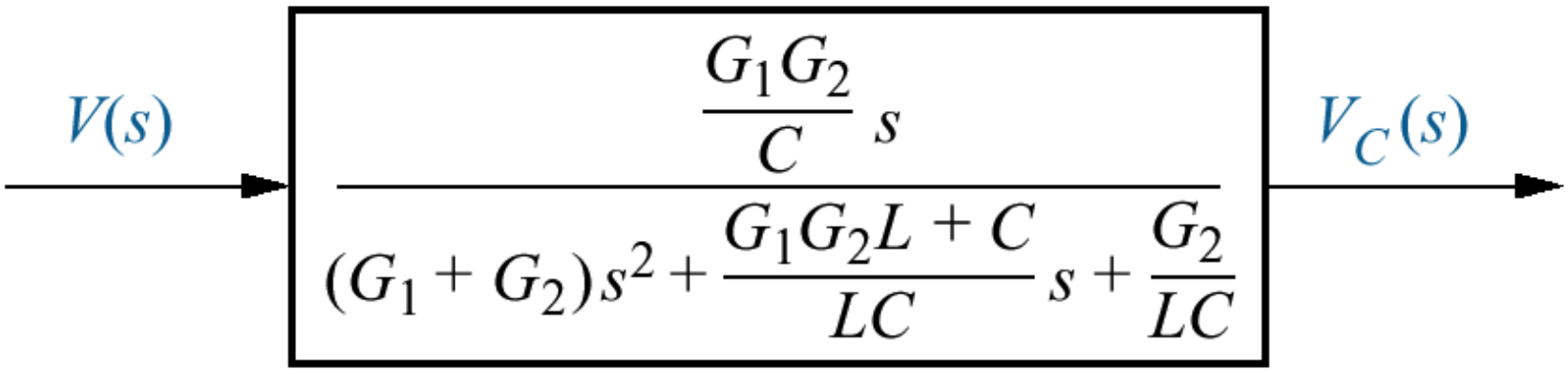


Figure 2.8
Transformed network ready for nodal analysis

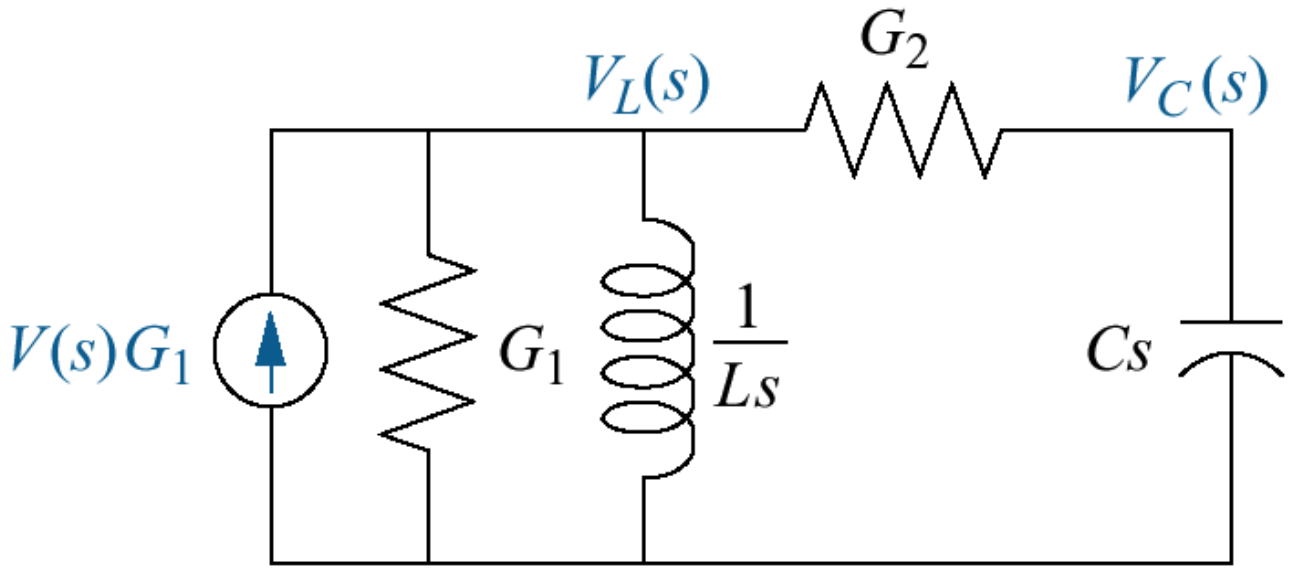


Figure 2.9
Three-loop electrical network

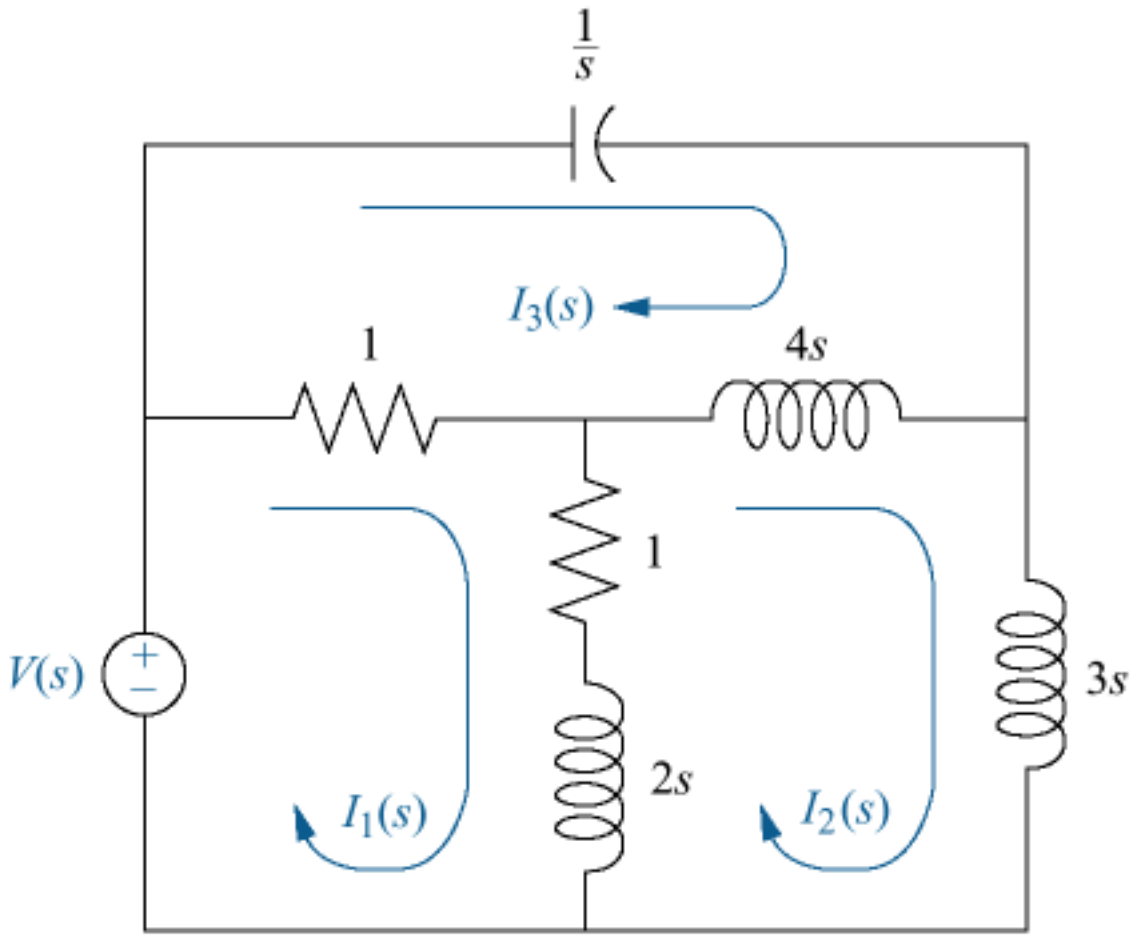


Figure 2.10
a. Operational amplifier;
b. schematic for an inverting operational amplifier;
c. inverting operational amplifier configured for transfer function realization. Typically, the amplifier gain, A, is omitted.

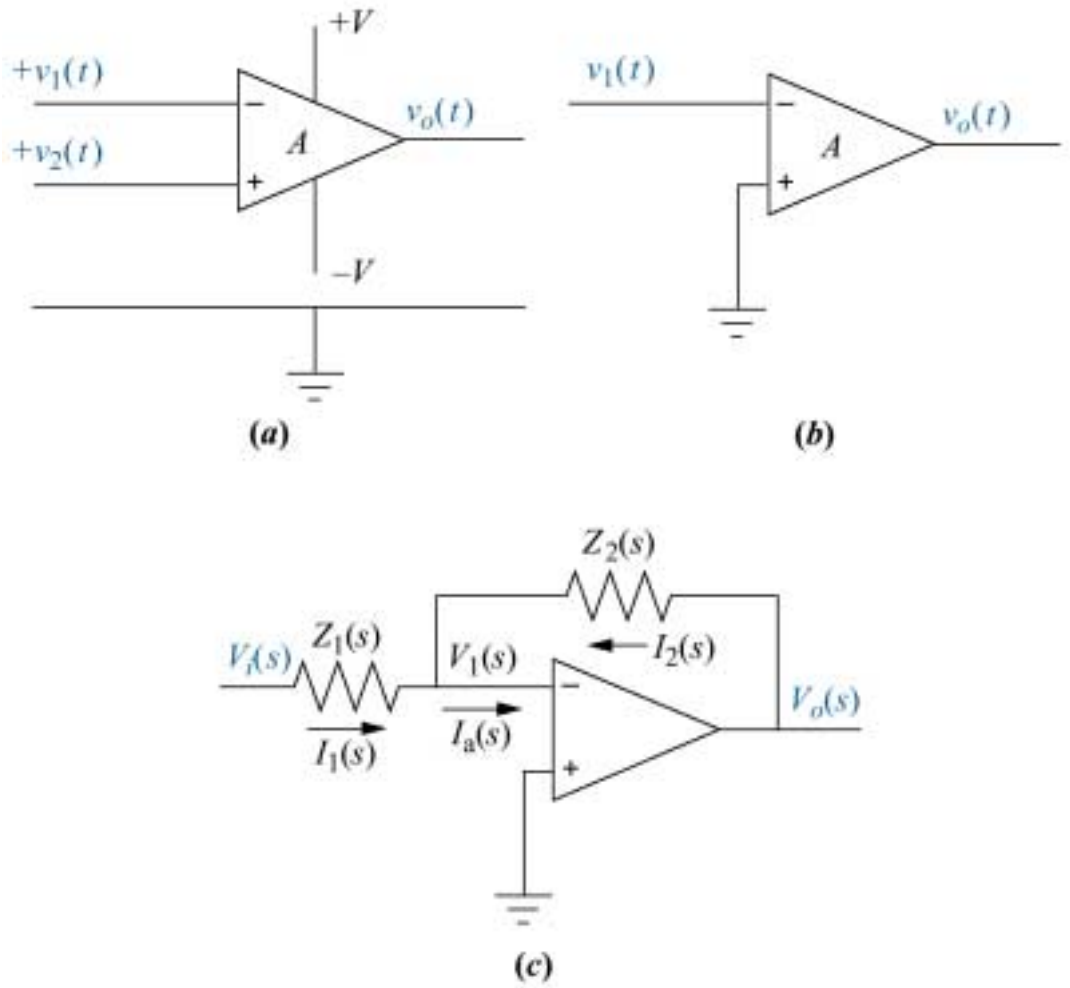


Figure 2.11
Inverting operational amplifier circuit for Example 2.14

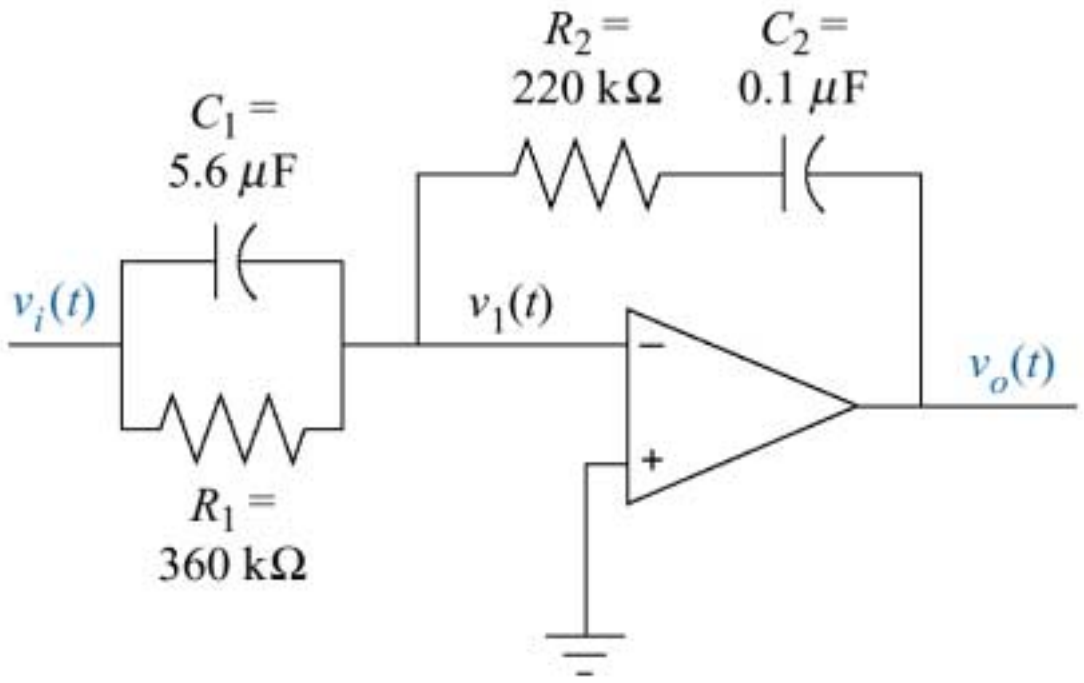


Figure 2.12
General noninverting operational amplifier circuit

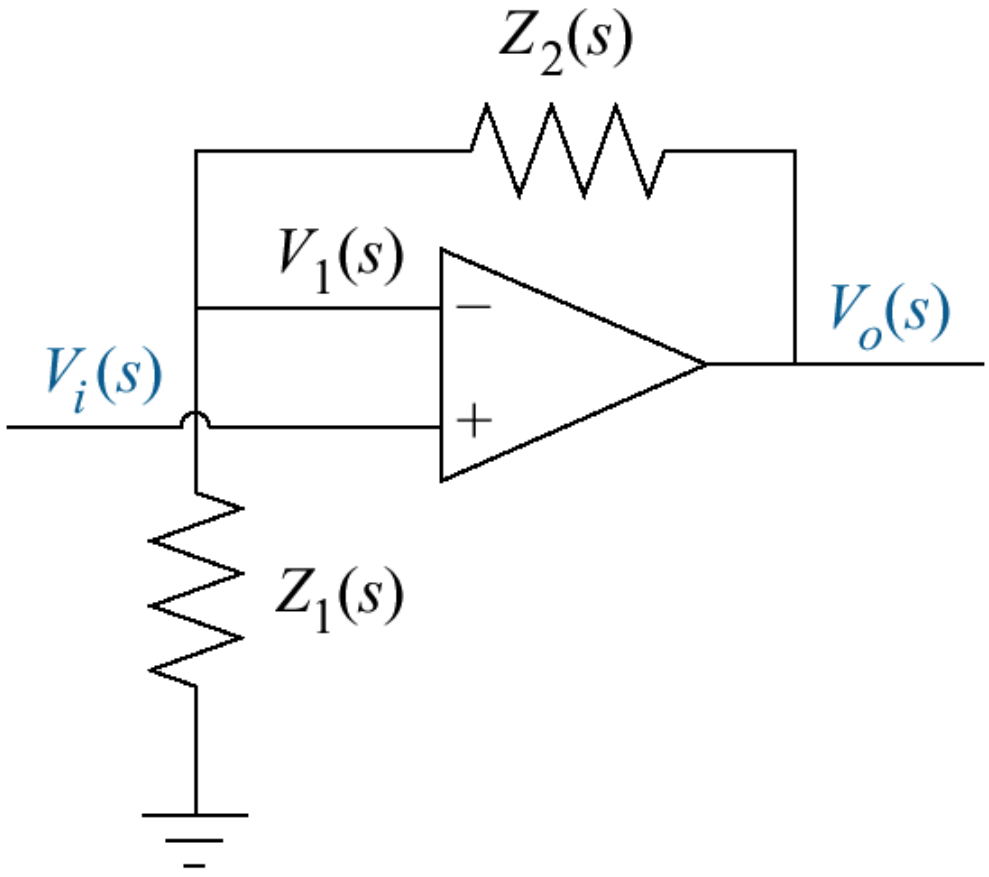


Figure 2.13
Noninverting operational amplifier circuit for Example 2.15

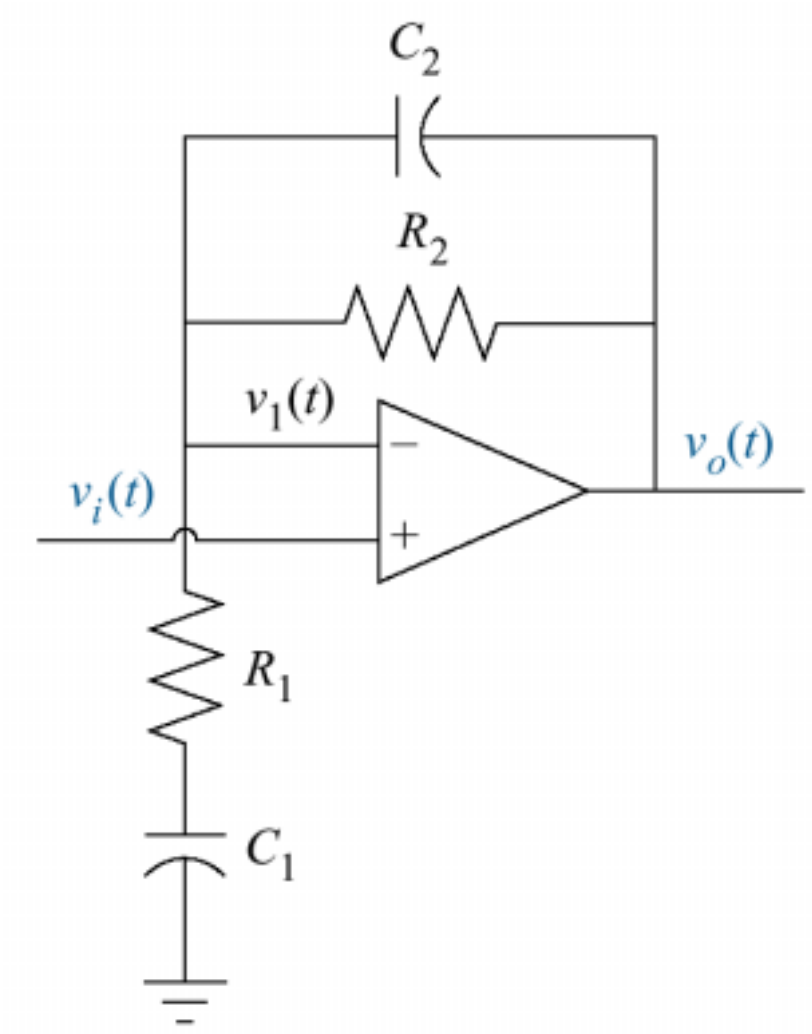


Figure 2.14
Electric circuit for Skill-Assessment Exercise 2.6

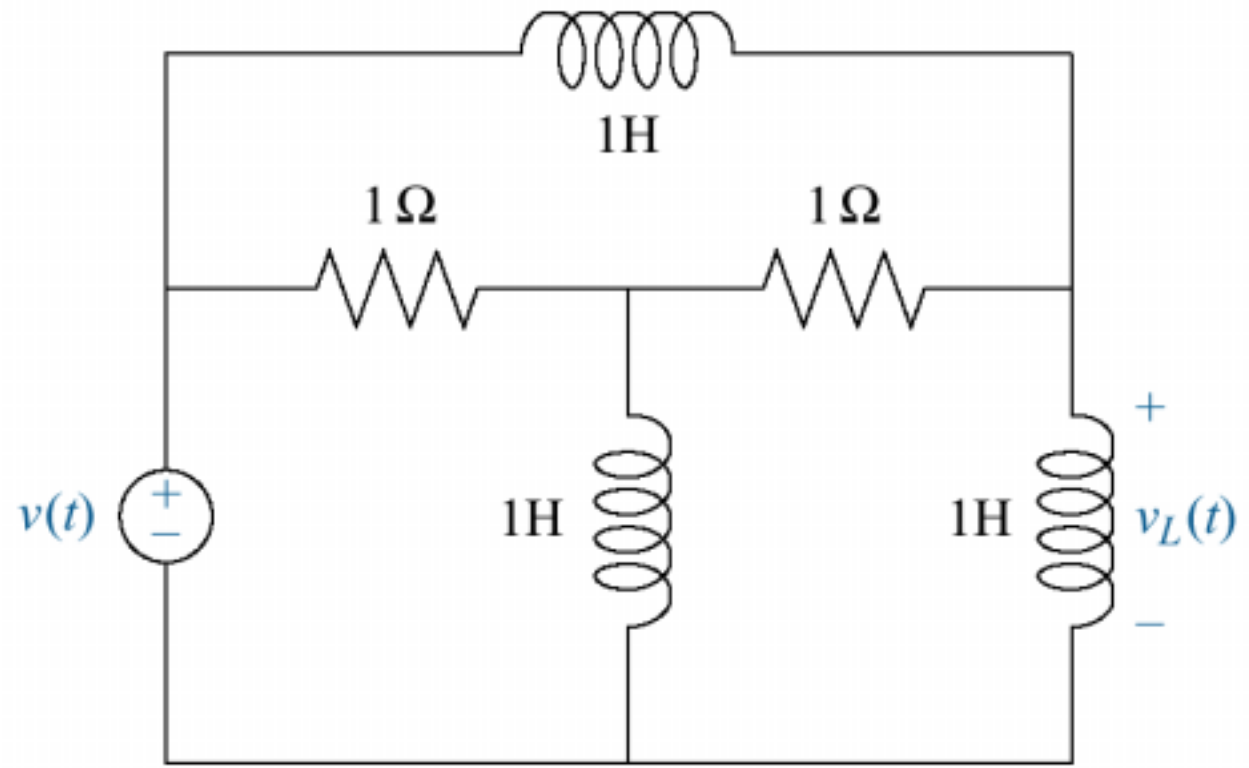


Figure 2.15
a. Mass, spring, and damper system;
b. block diagram

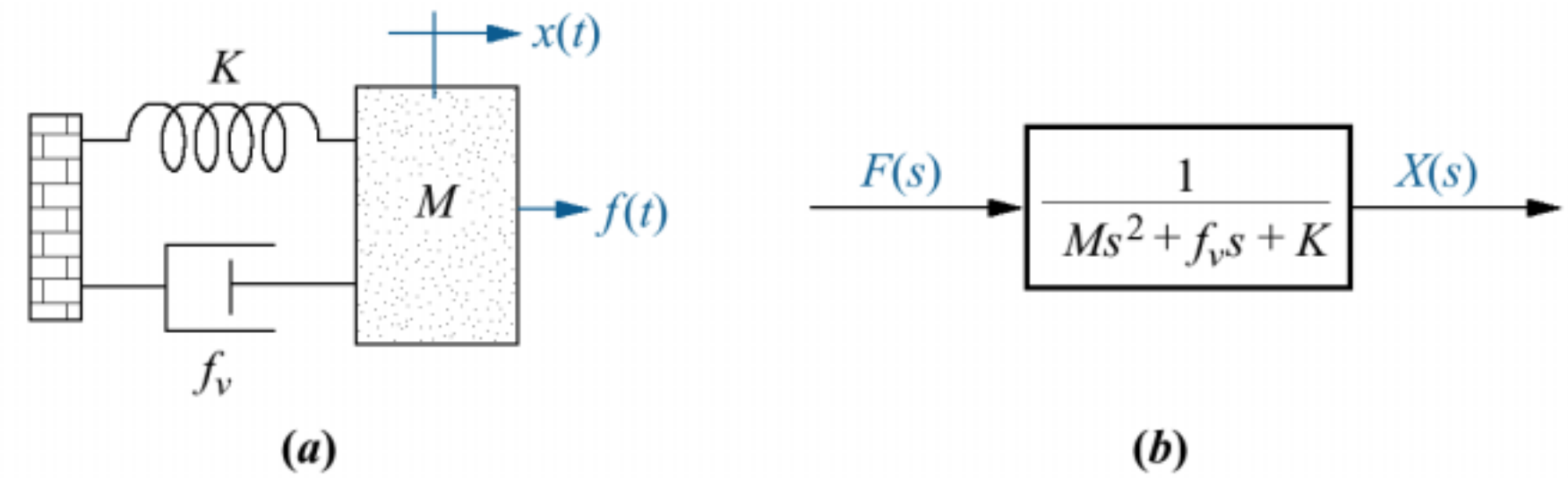


Figure 2.16
a. Free-body diagram of mass, spring, and damper system;
b. transformed free-body diagram

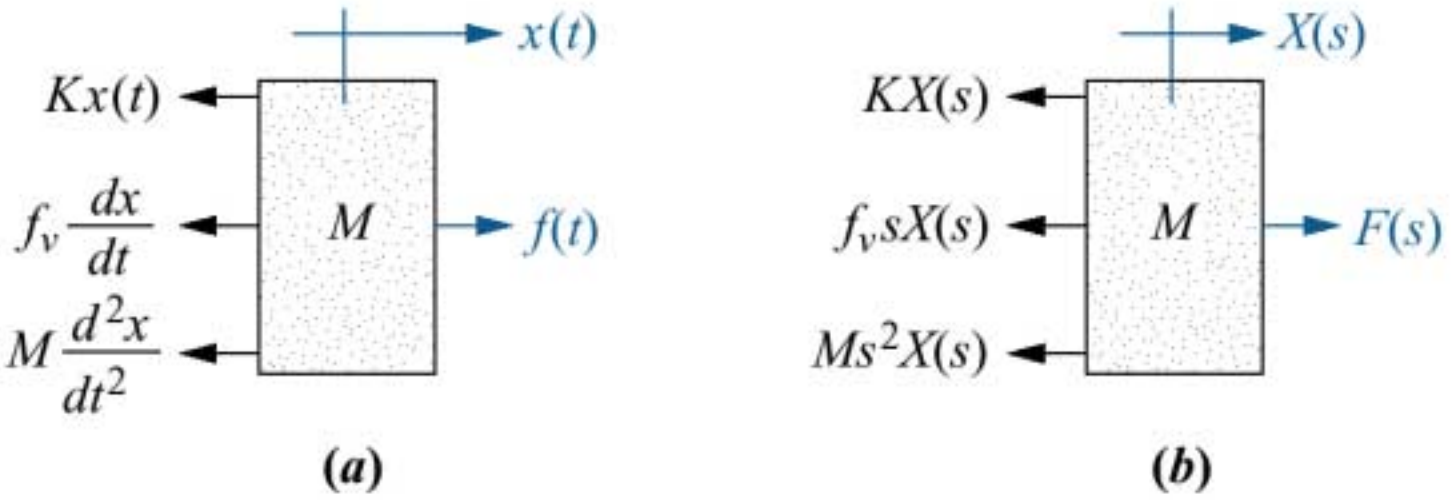


Figure 2.17
a. Two-degrees-of-freedom translational mechanical system[8];
b. block diagram

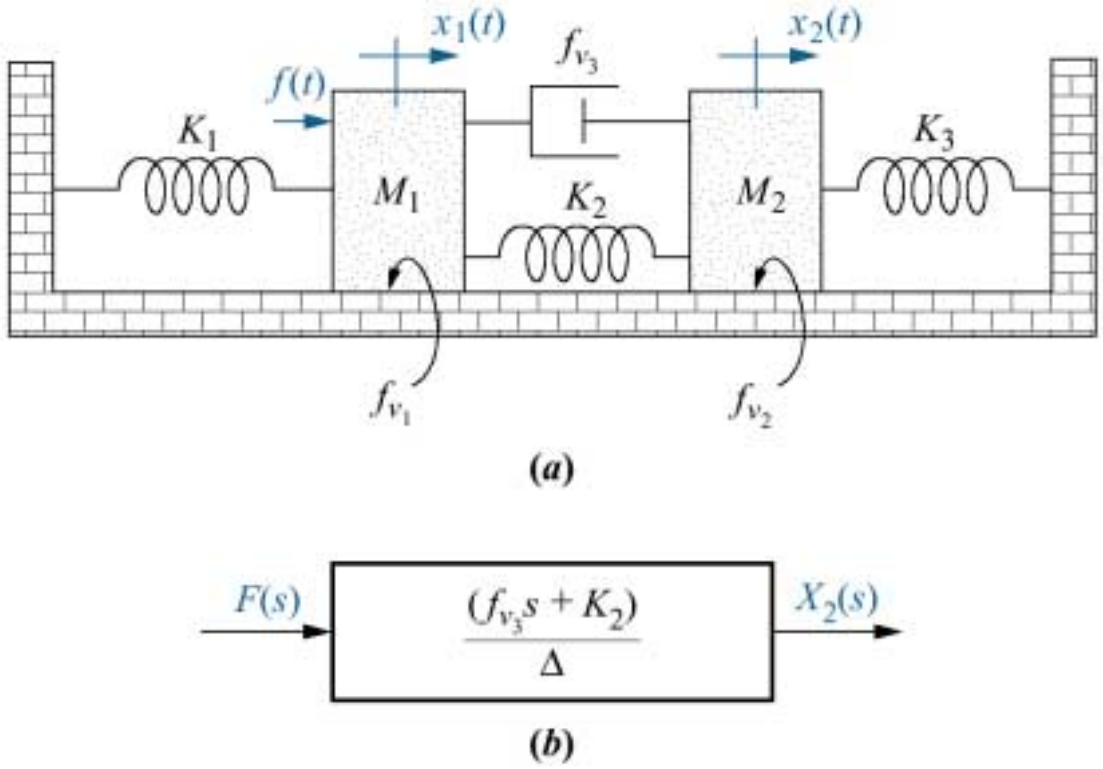


Figure 2.18
a. Forces on M_1 due only to motion of M_1
b. forces on M_1 due only to motion of M_2
c. all forces on M_1

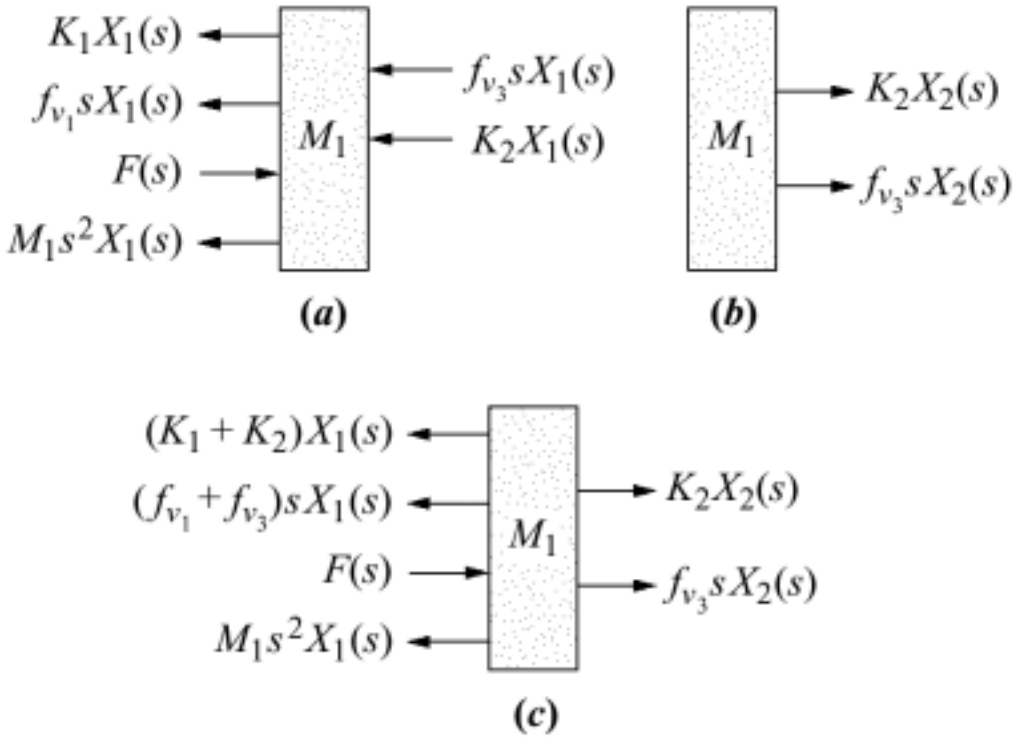


Figure 2.19
a. Forces on M_2 due only to motion of M_2;
b. forces on M_2 due only to motion of M_1;
c. all forces on M_2

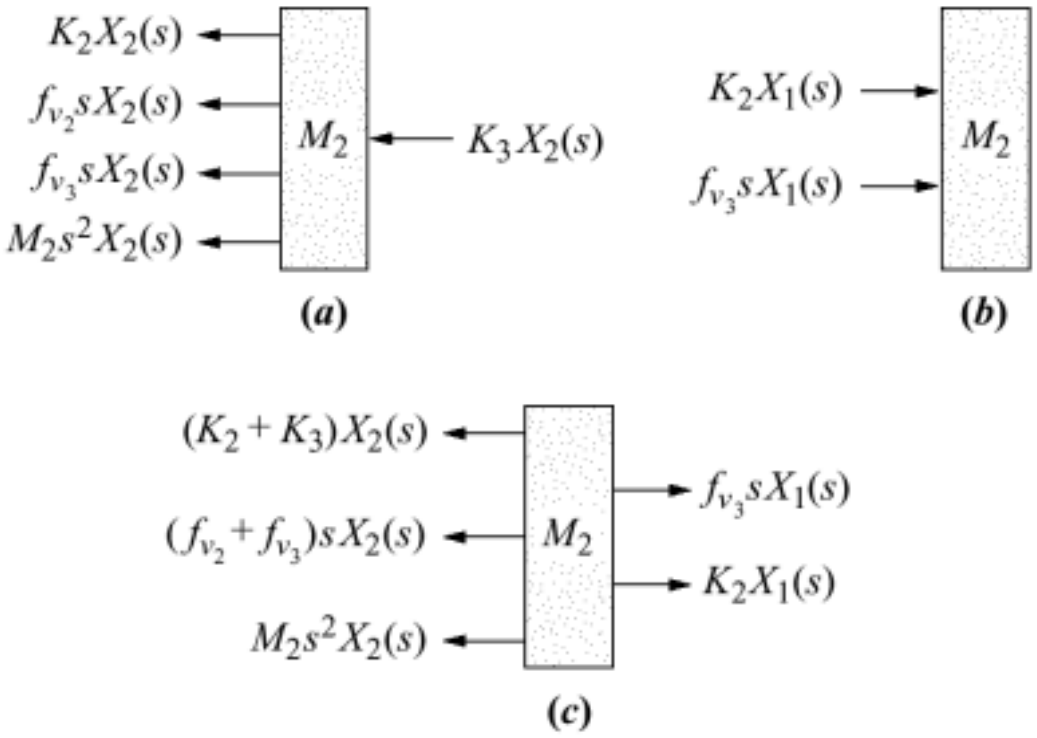


Figure 2.20
Three-degrees-of-freedom translational mechanical system

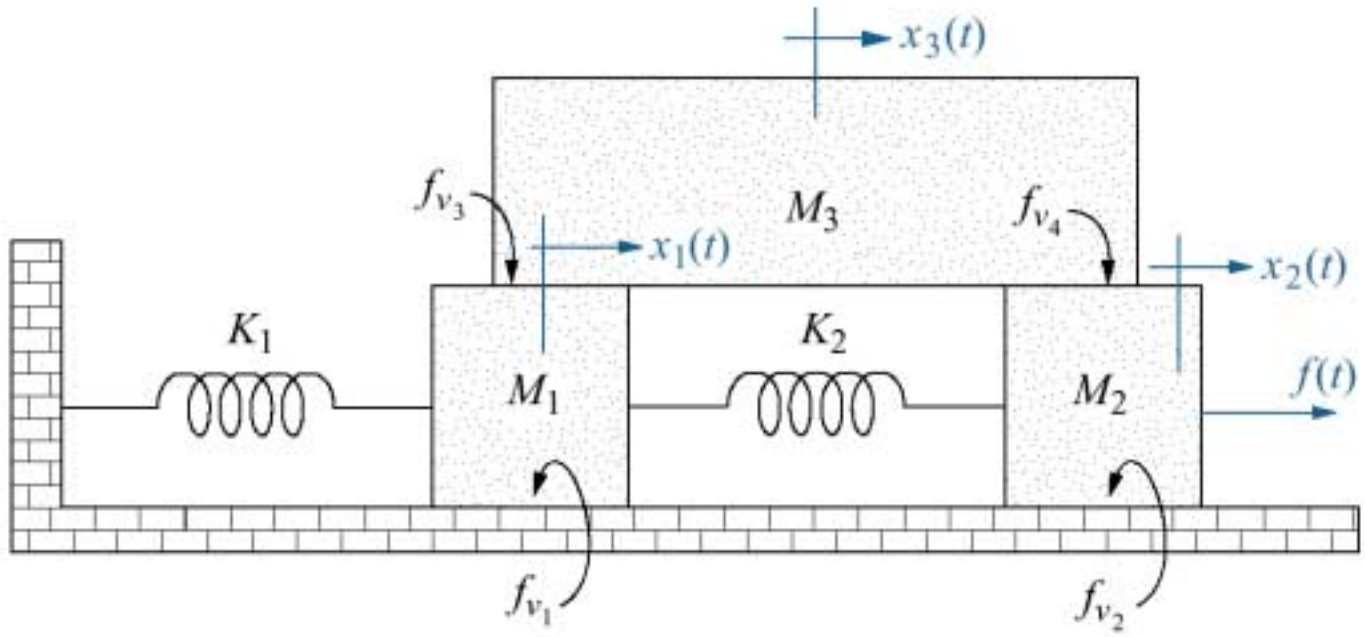


Figure 2.21
Translational mechanical system for Skill-Assessment Exercise 2.8

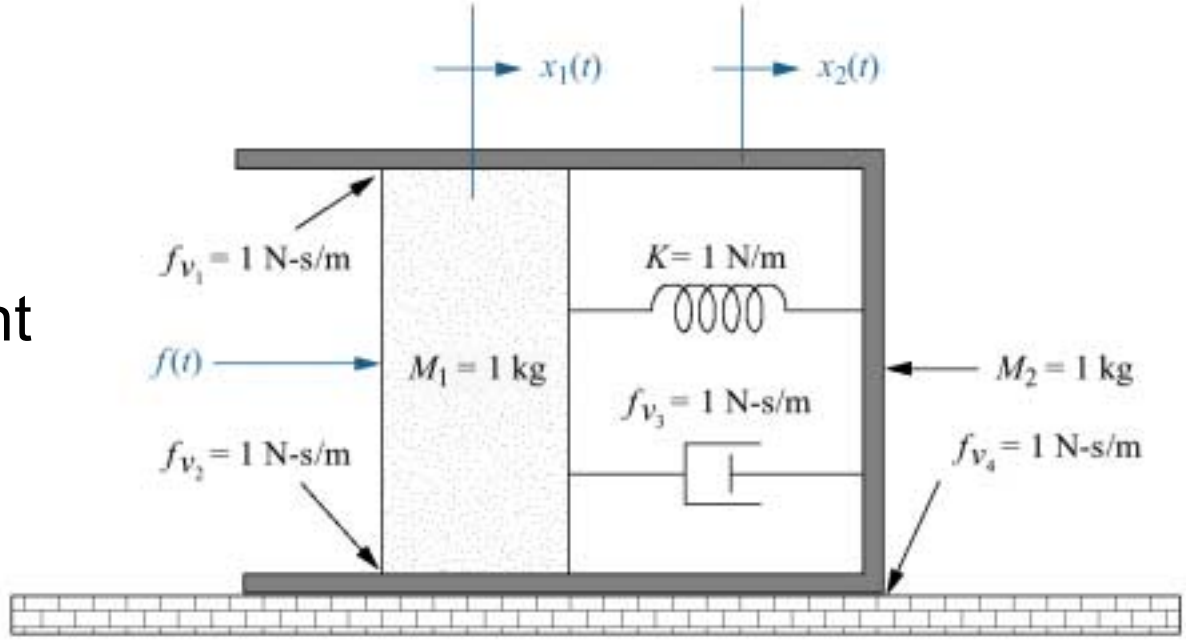


Figure 2.22
a. Physical system;
b. schematic;
c. block diagram

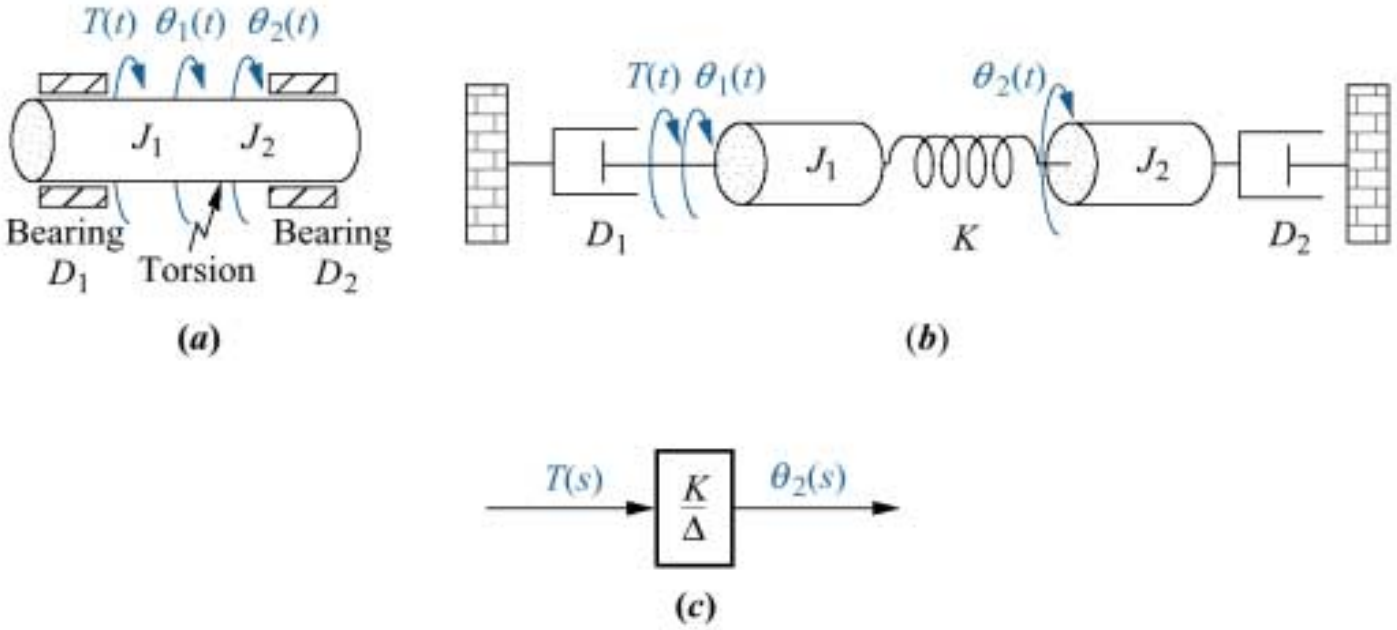


Figure 2.23
a. Torques on J_1 due only to the motion of J_1
b. torques on J_1 due only to the motion of J_2
c. final free-body diagram for J_1

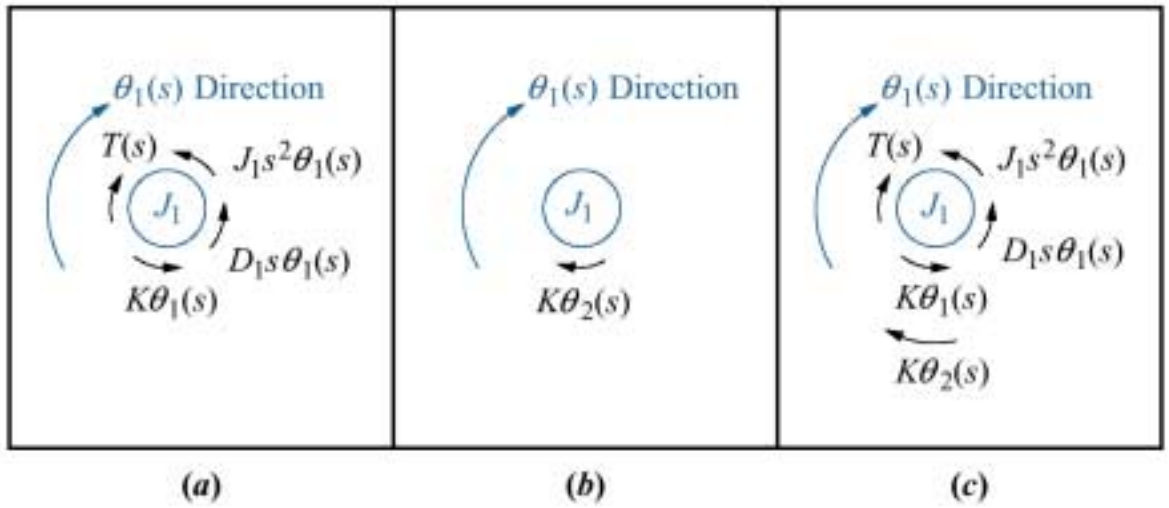


Figure 2.24
a. Torques on J_2 due only to the motion of J_2;
b. torques on J_2 due only to the motion of J_1
c. final free-body diagram for J_2

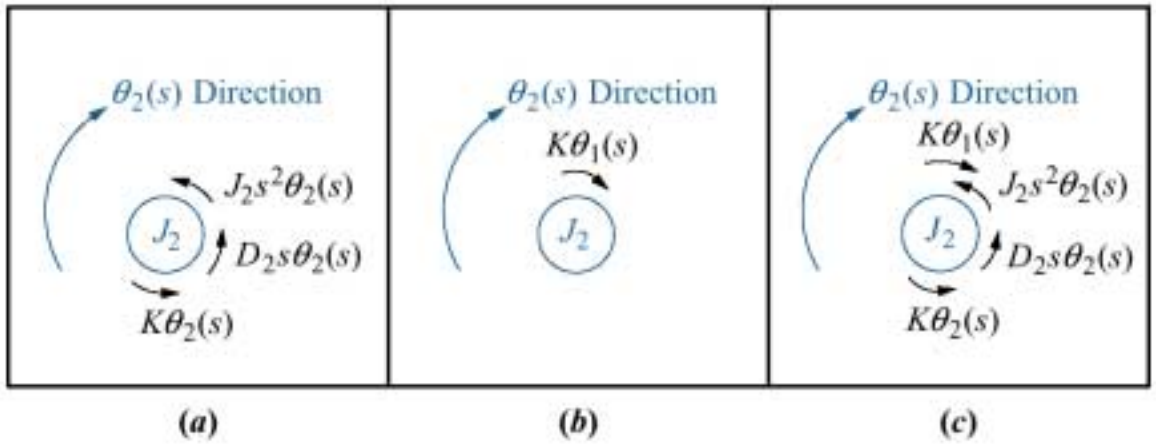


Figure 2.25
Three-degrees-of-freedom rotational system

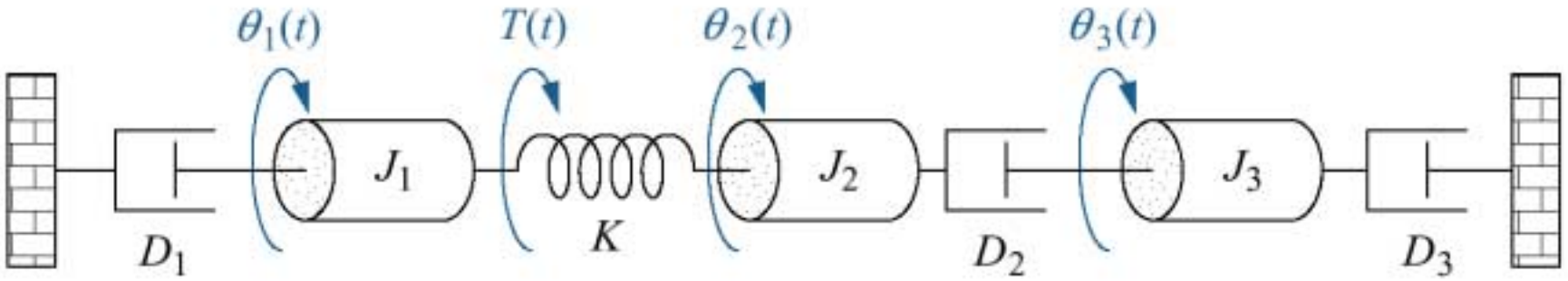


Figure 2.26
Rotational mechanical system for Skill-Assessment Exercise 2.9

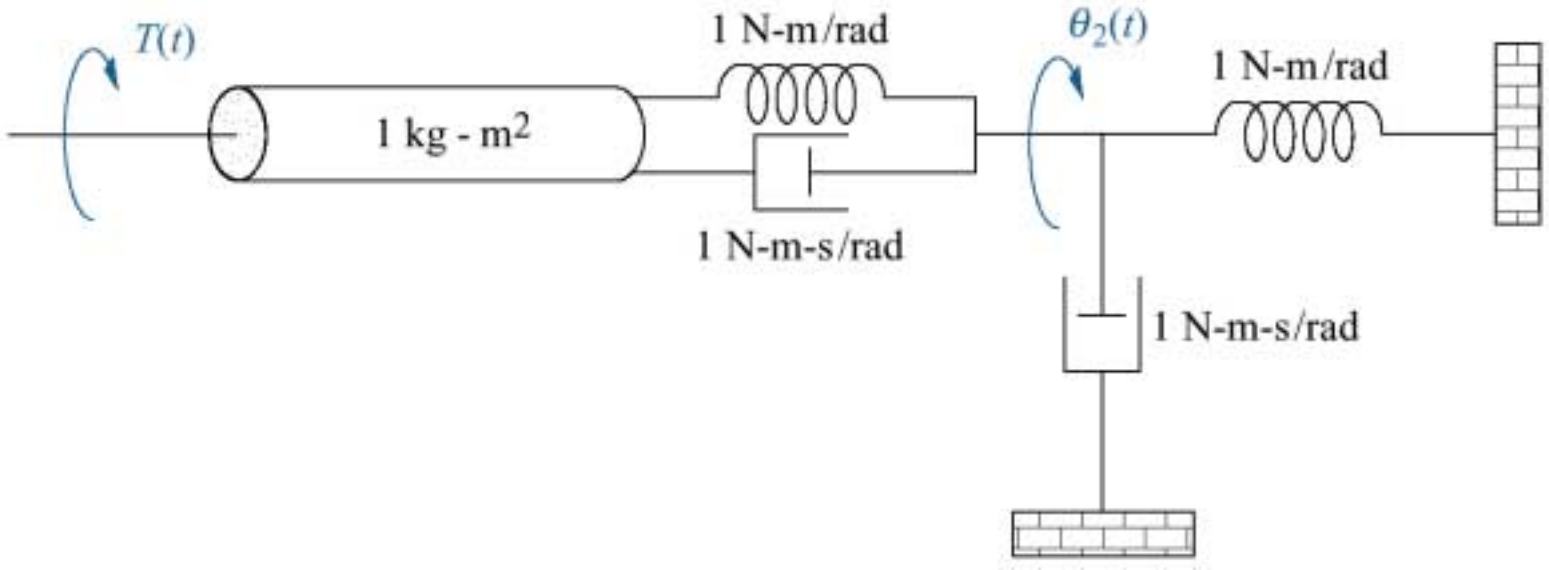


Figure 2.27
A gear system

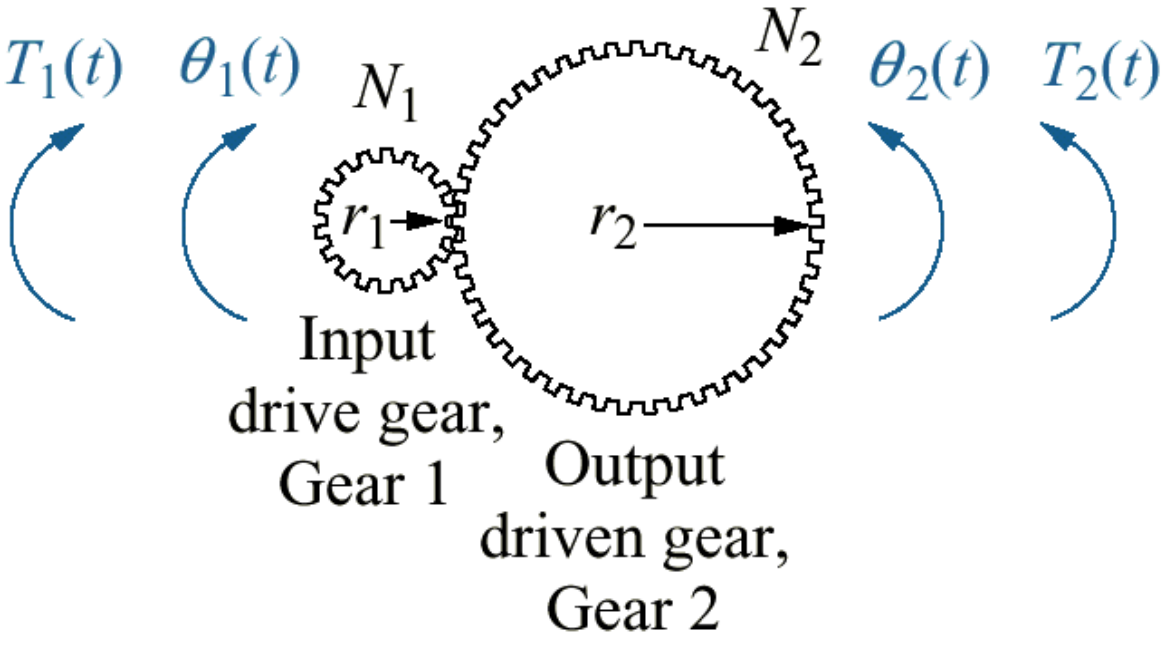


Figure 2.28
Transfer functions for
a. angular displacement in lossless gears and
b. torque in lossless gears

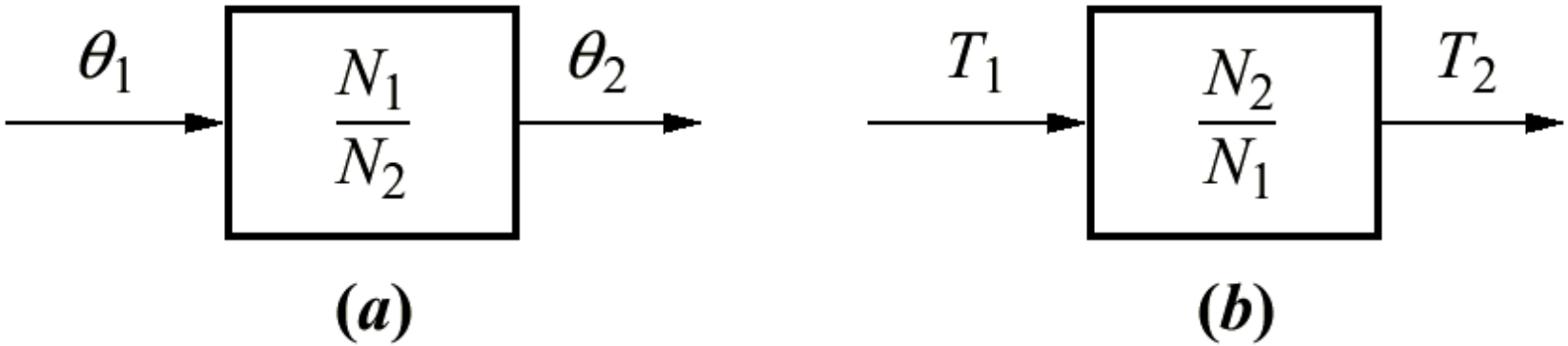


Figure 2.29
a. Rotational system driven by gears;
b. equivalent system at the output after reflection of input torque;
c. equivalent system at the input after reflection of impedances

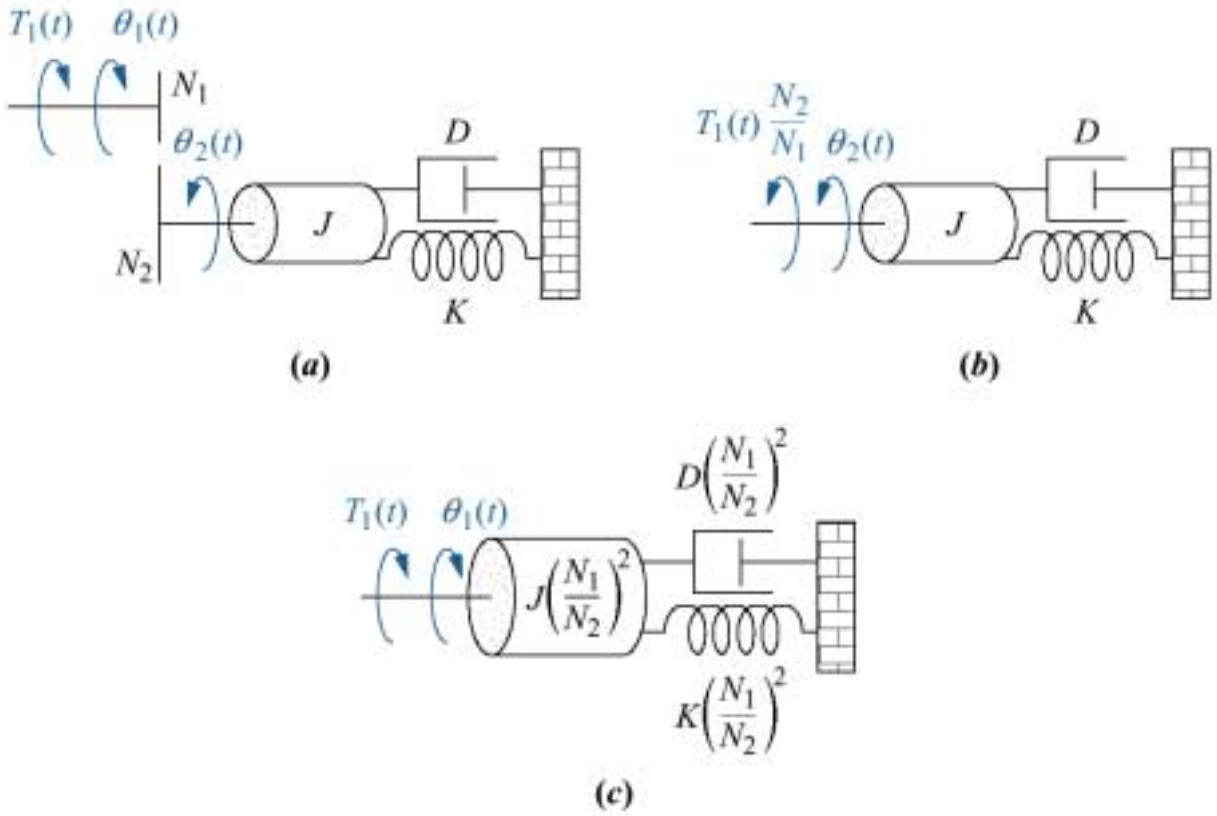


Figure 2.30

a. Rotational mechanical system with gears;

b. system after reflection of torques and impedance to the output shaft;

c. block diagram

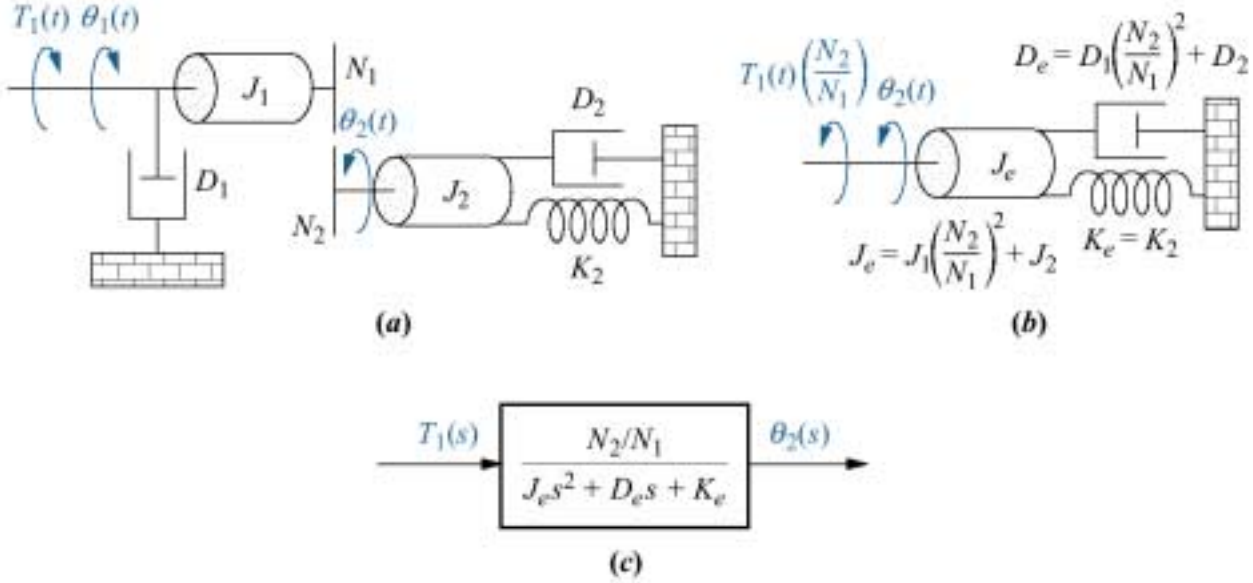


Figure 2.31
Gear train

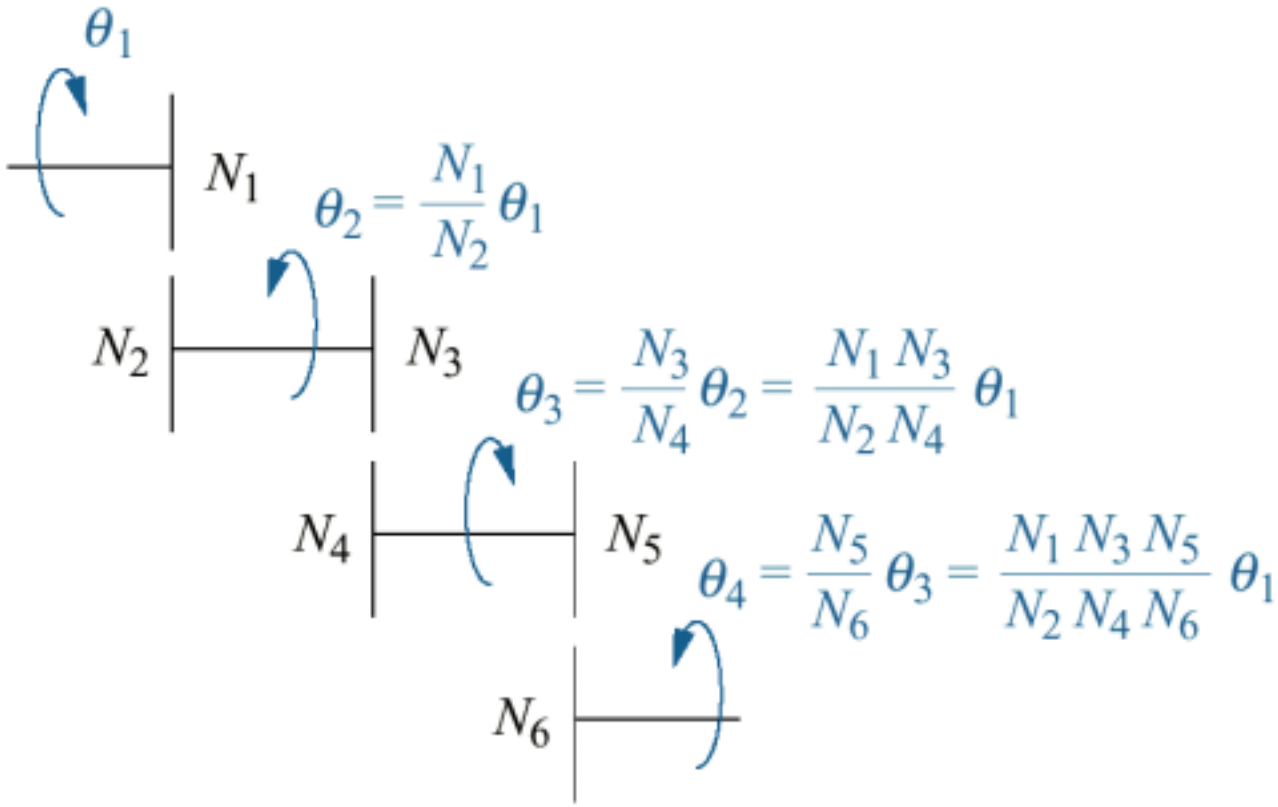


Figure 2.32

a. System using a gear train;

b. equivalent system at the input;

c. block diagram

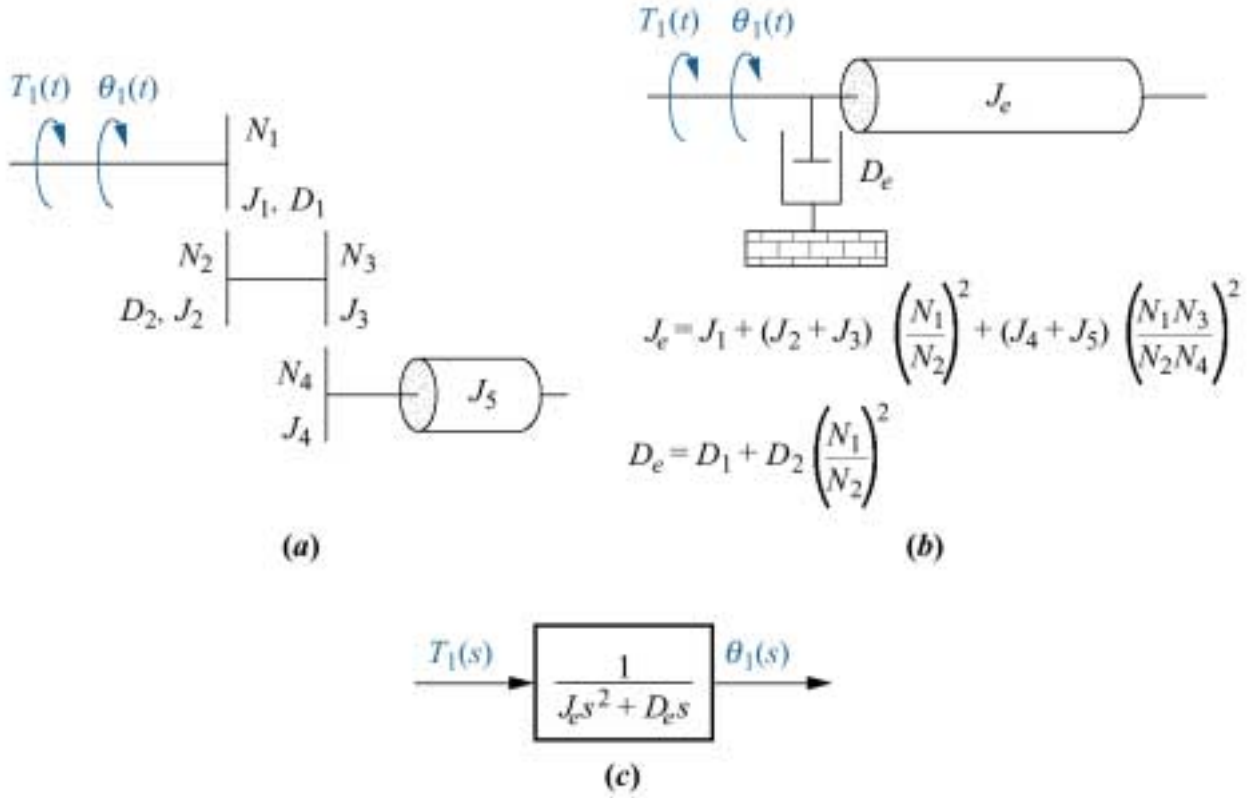


Figure 2.33
Rotational mechanical system with gears for Skill-Assessment Exercise 2.10

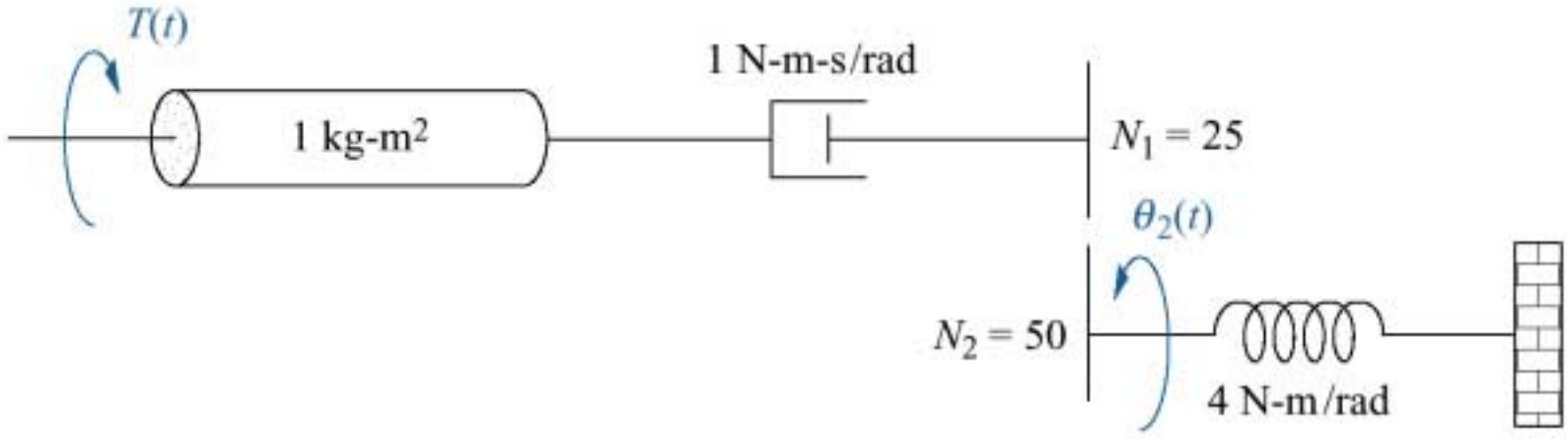


Figure 2.34
NASA flight simulator robot arm with electromechanical control system components

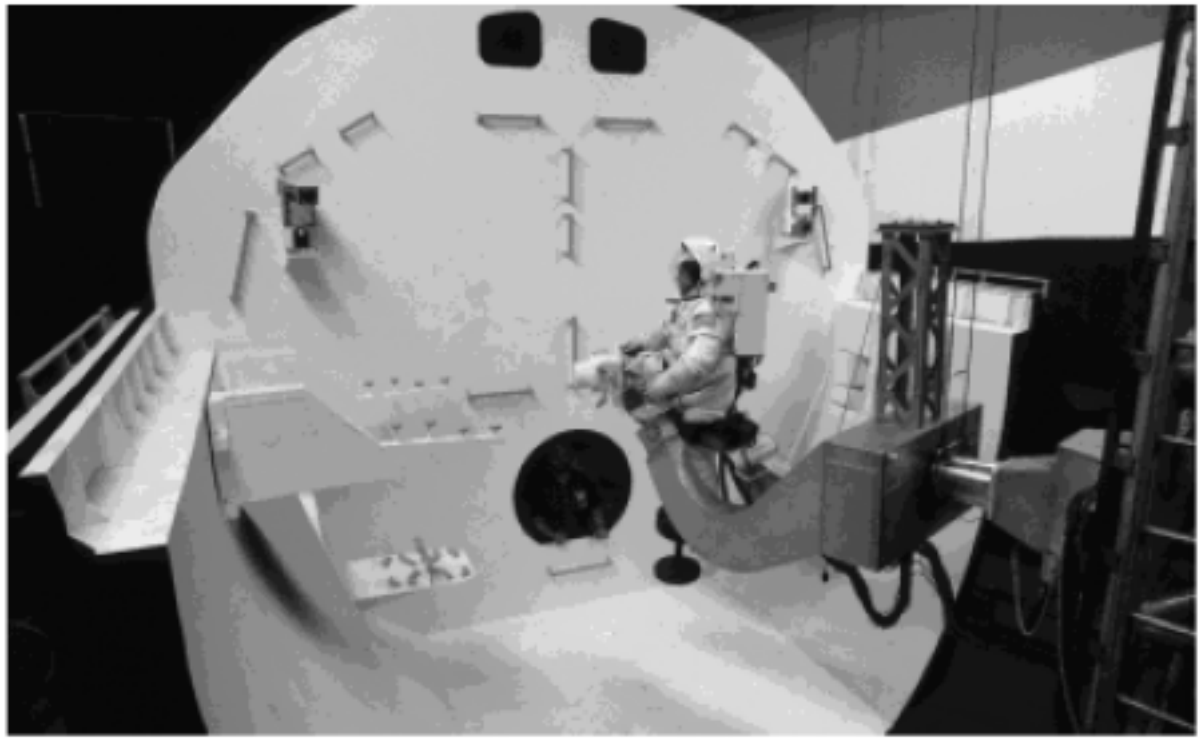


Figure 2.35
DC motor:
a. schematic[12];
b. block diagram

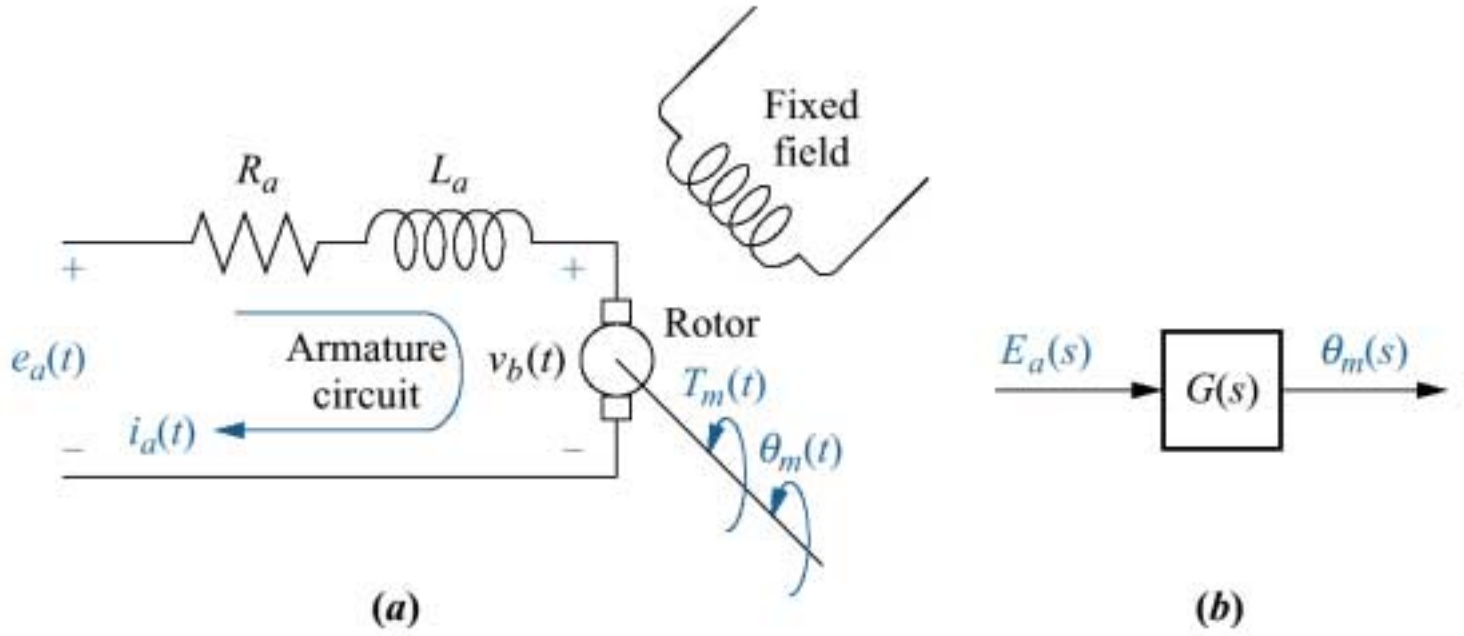


Figure 2.36
Typical equivalent mechanical loading on a motor

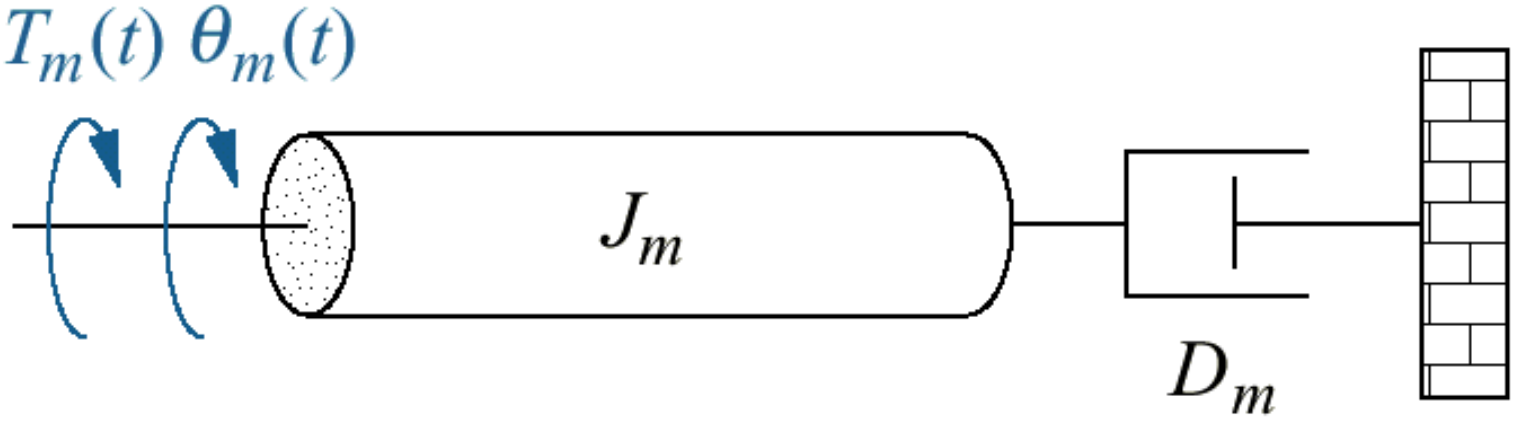


Figure 2.37
DC motor driving a rotational mechanical load

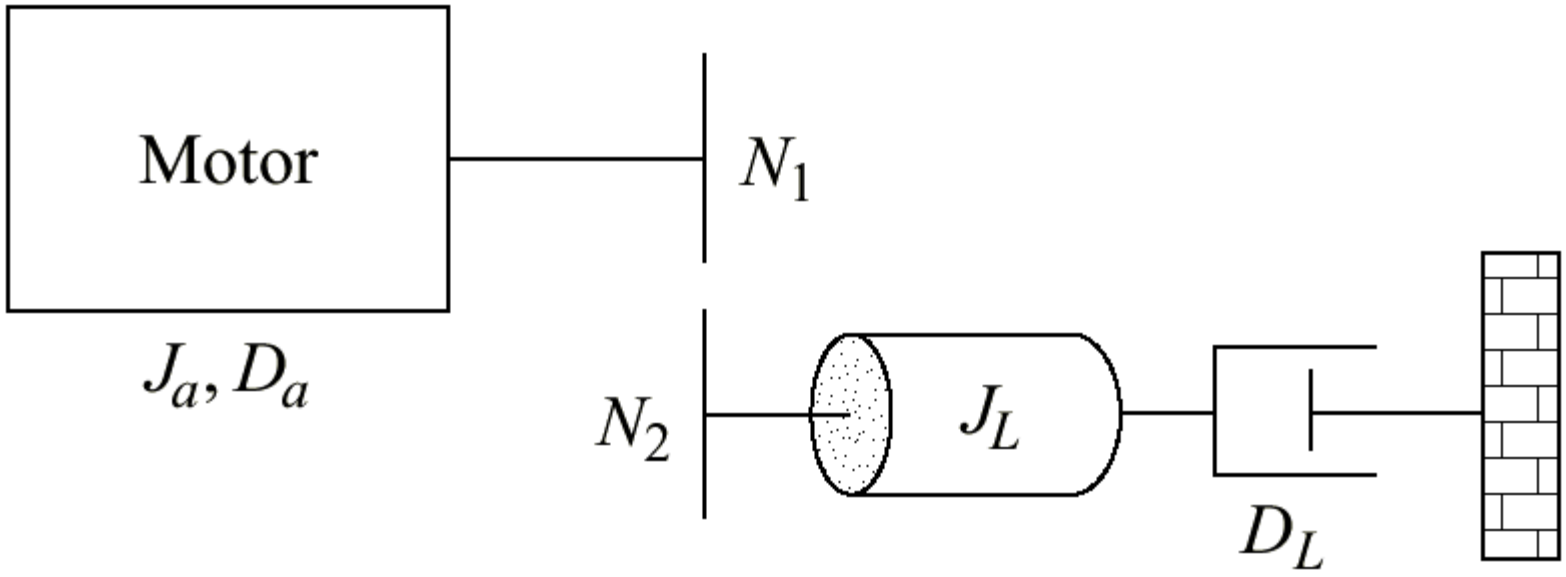


Figure 2.38
Torque-speed curves with an armature voltage, e_a, as a parameter

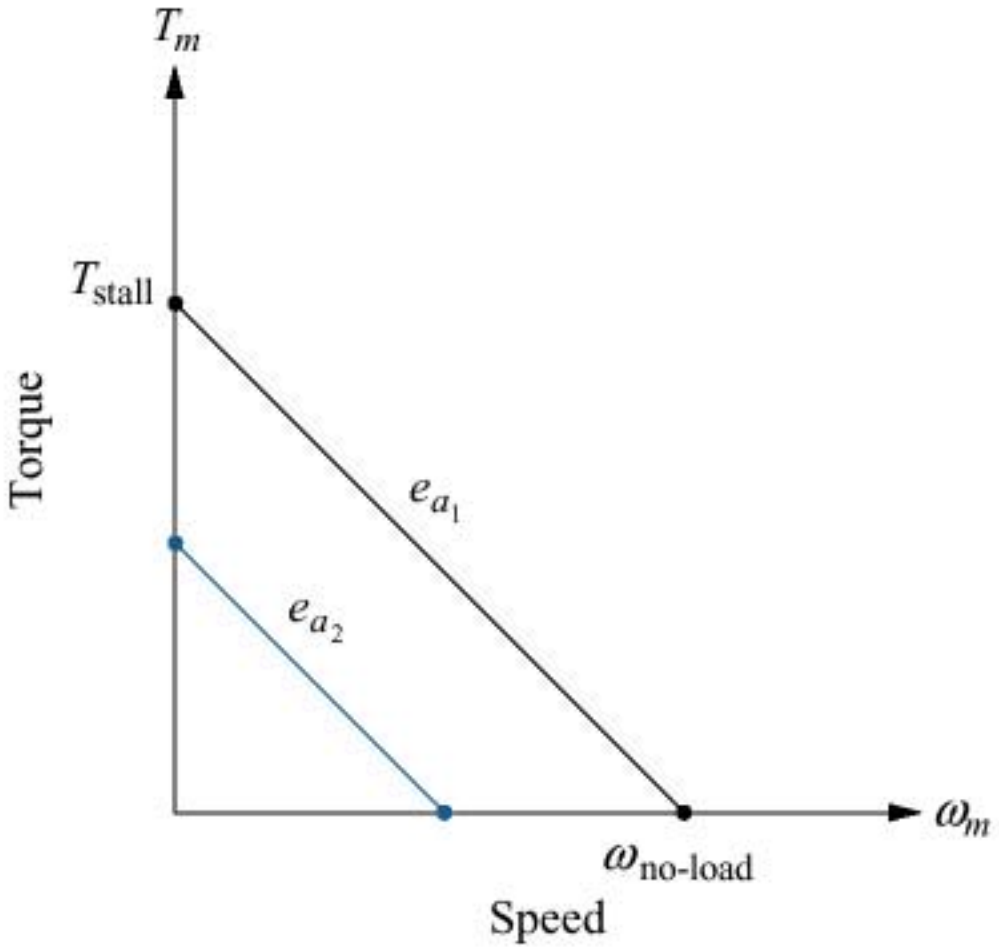


Figure 2.39
a. DC motor and load;
b. torque-speed curve;
c. block diagram

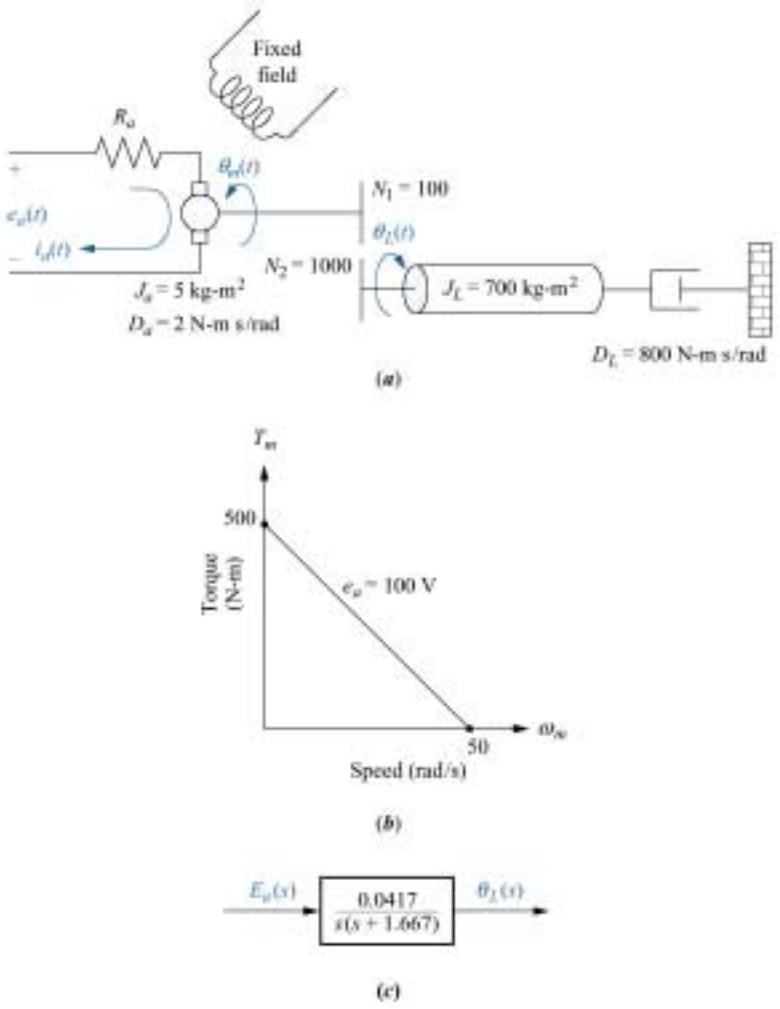


Figure 2.40
Electromechanical system for Skill-Assessment Exercise 2.11

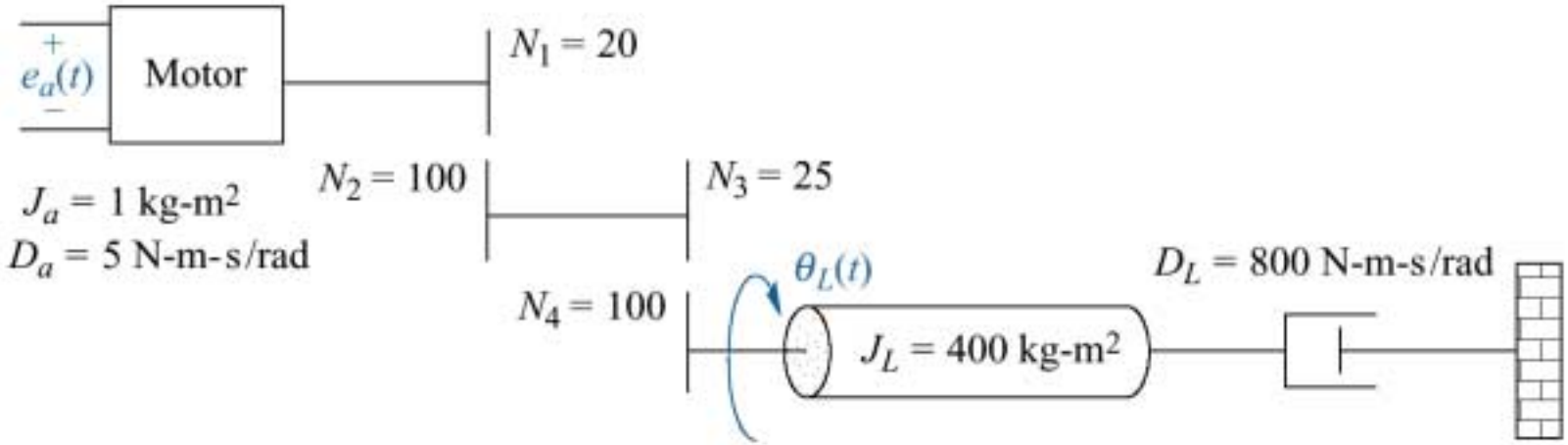


Figure 2.41
Development of series analog:
a. mechanical system;
b. desired electrical representation;
c. series analog;
d. parameters for series analog

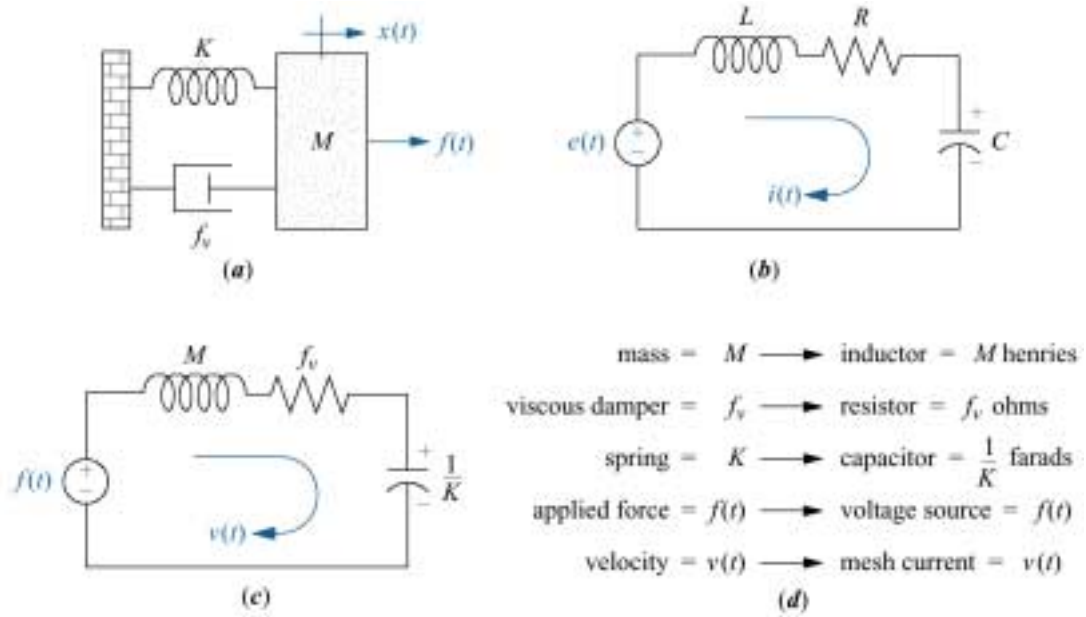


Figure 2.42
Series analog of mechanical system of Figure 2.17(a)

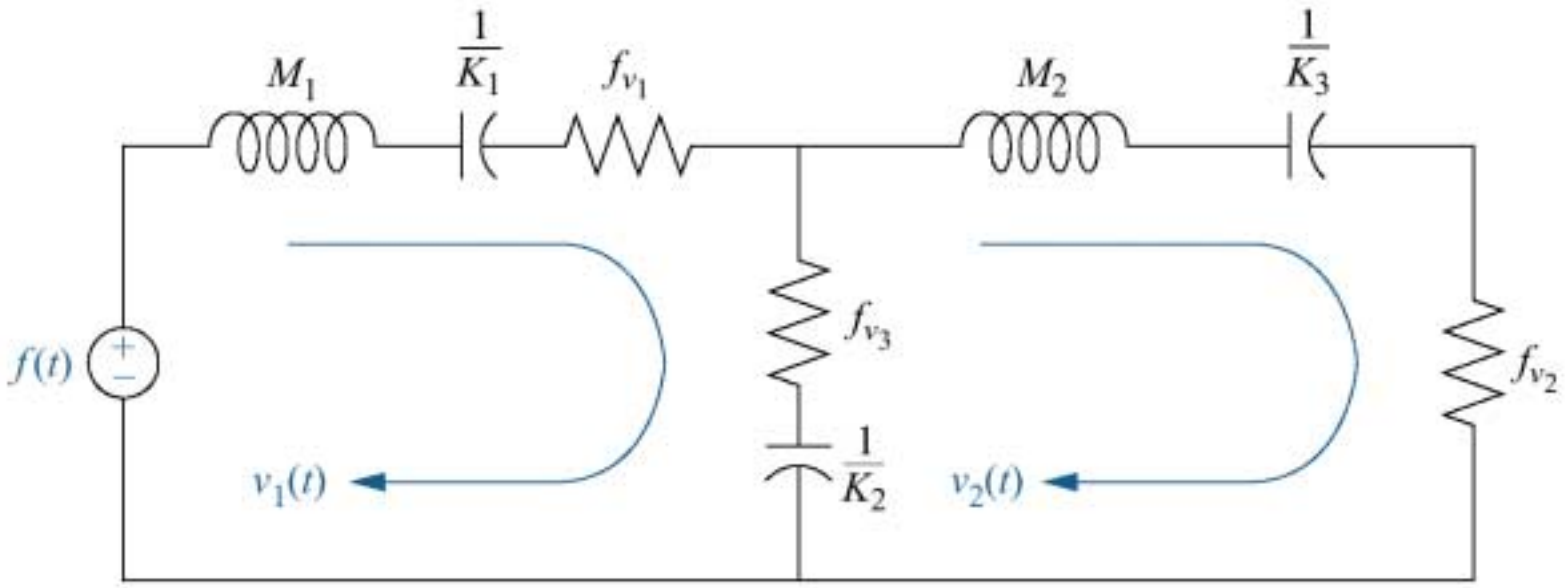


Figure 2.43
Development of parallel analog:
a. mechanical system;
b. desired electrical representation;
c. parallel analog;
d. parameters for parallel analog

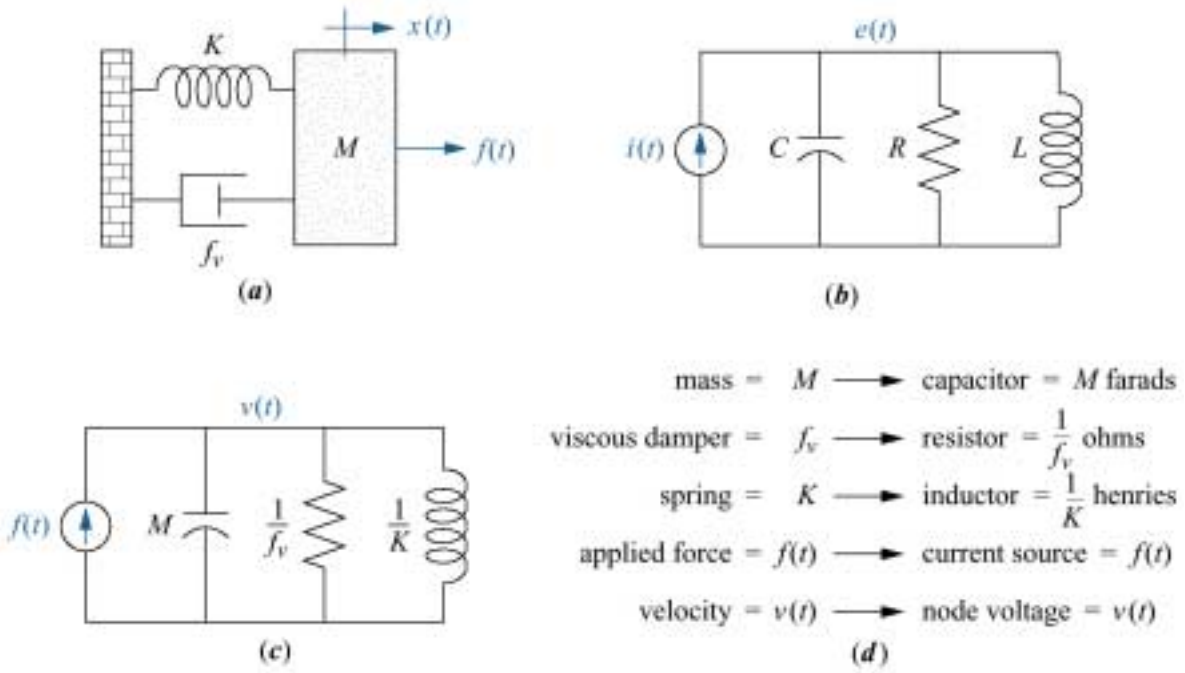


Figure 2.44
Parallel analog of mechanical system of Figure 2.17(a)

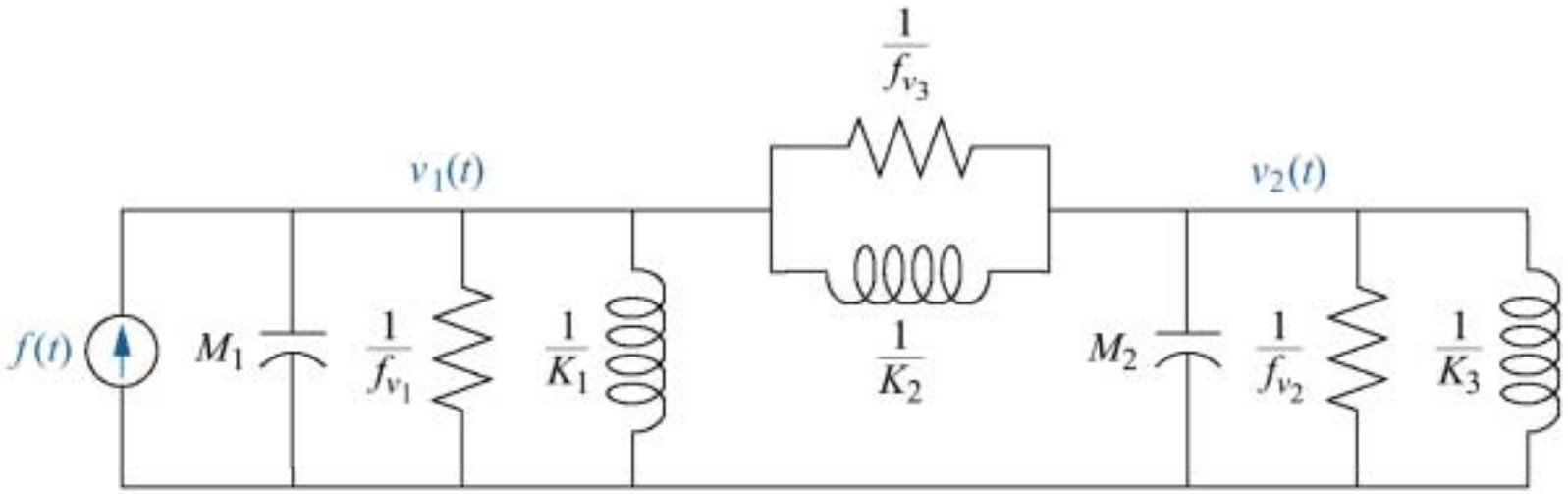


Figure 2.45
a. Linear system;
b. nonlinear system

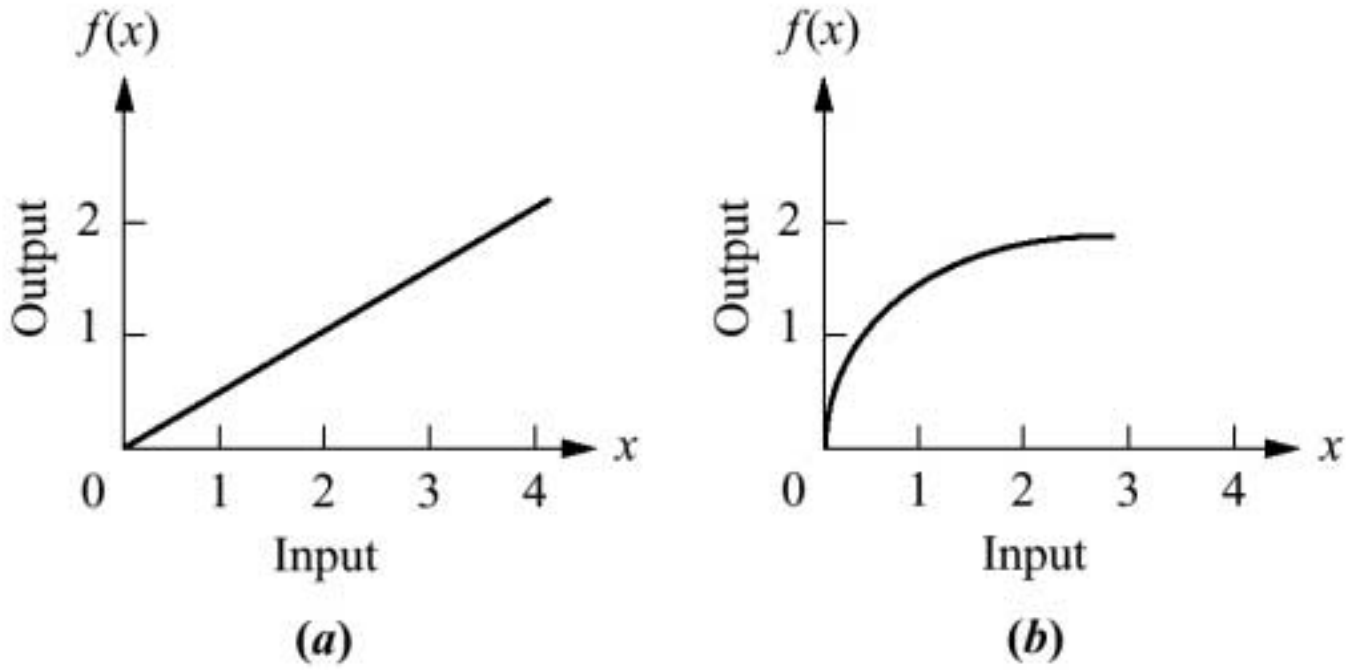


Figure 2.46
Some physical nonlinearities

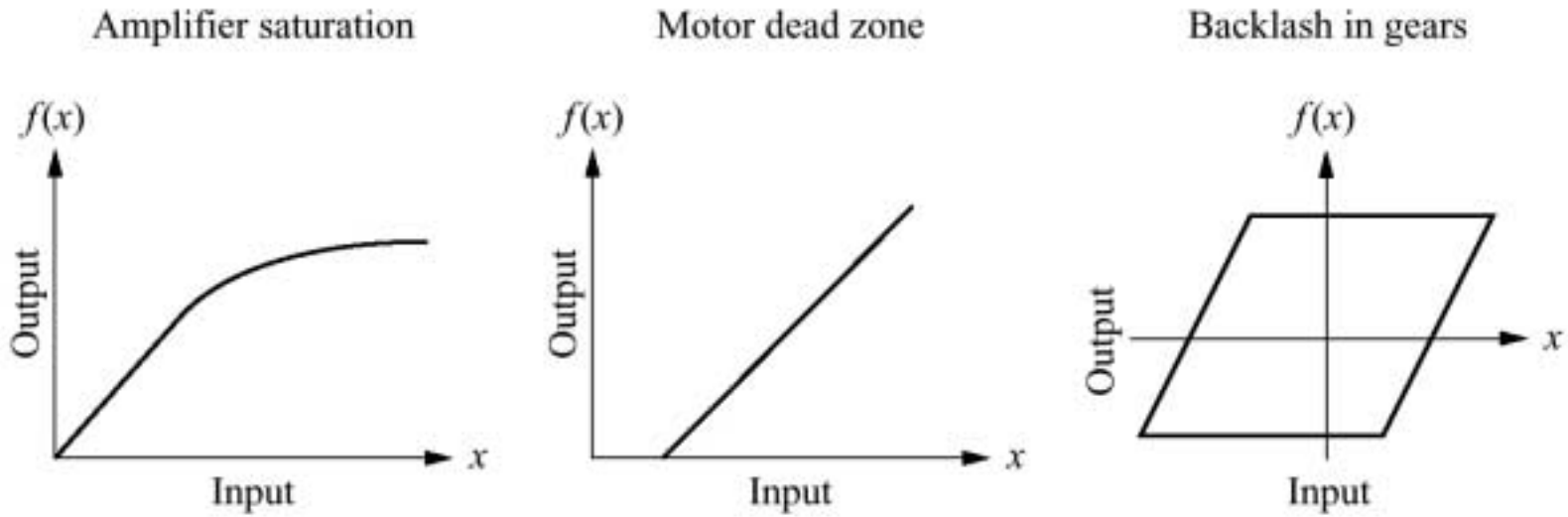


Figure 2.47
Linearization about a point A

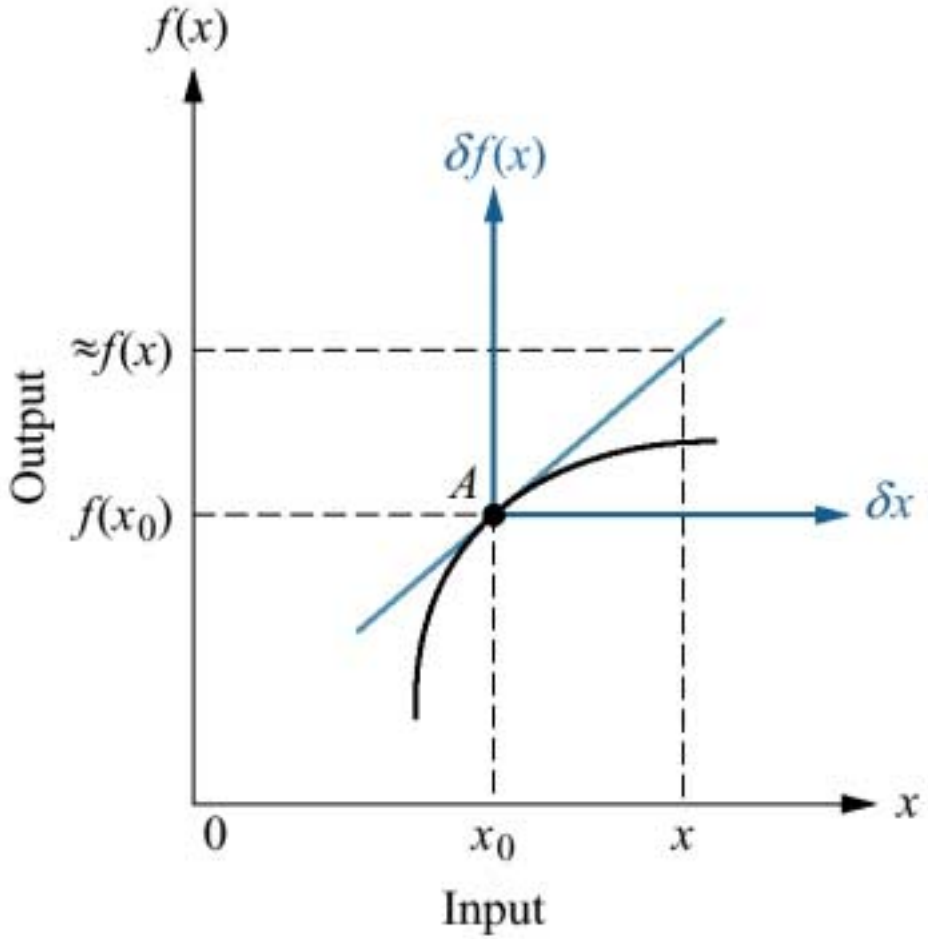


Figure 2.48
Linearization of 5 cos *x* about x = p/2

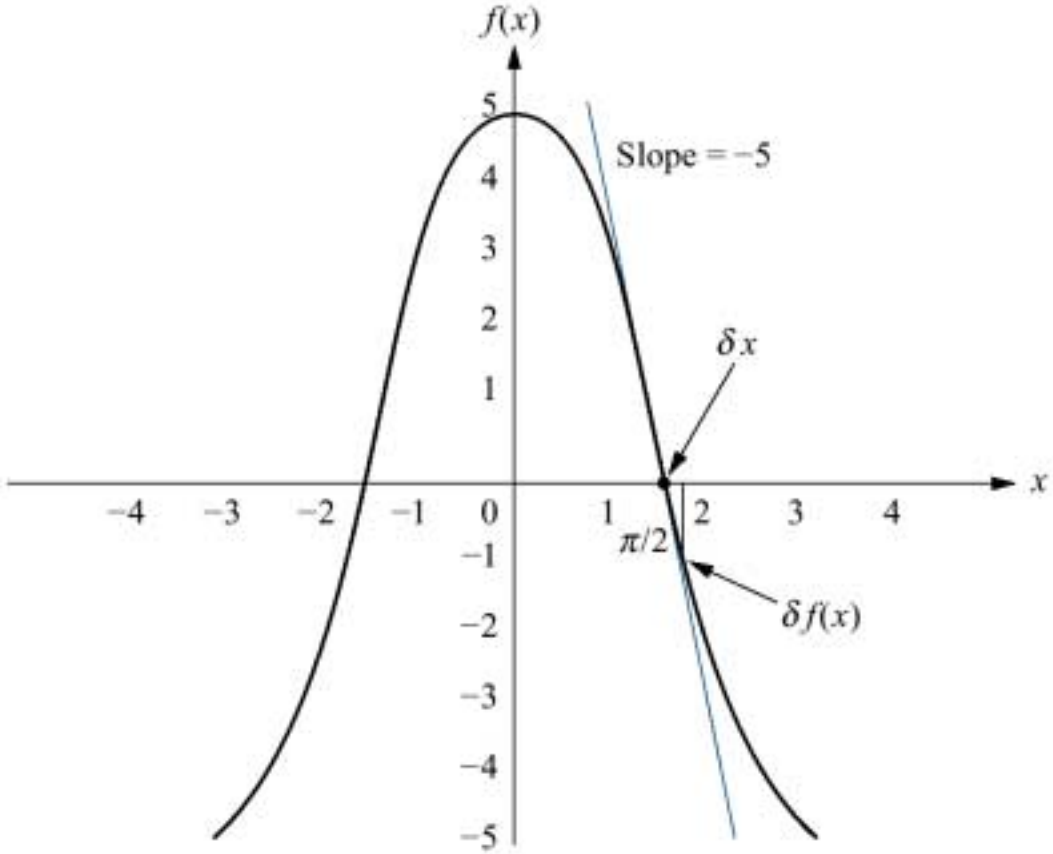


Figure 2.49
Nonlinear electrical network

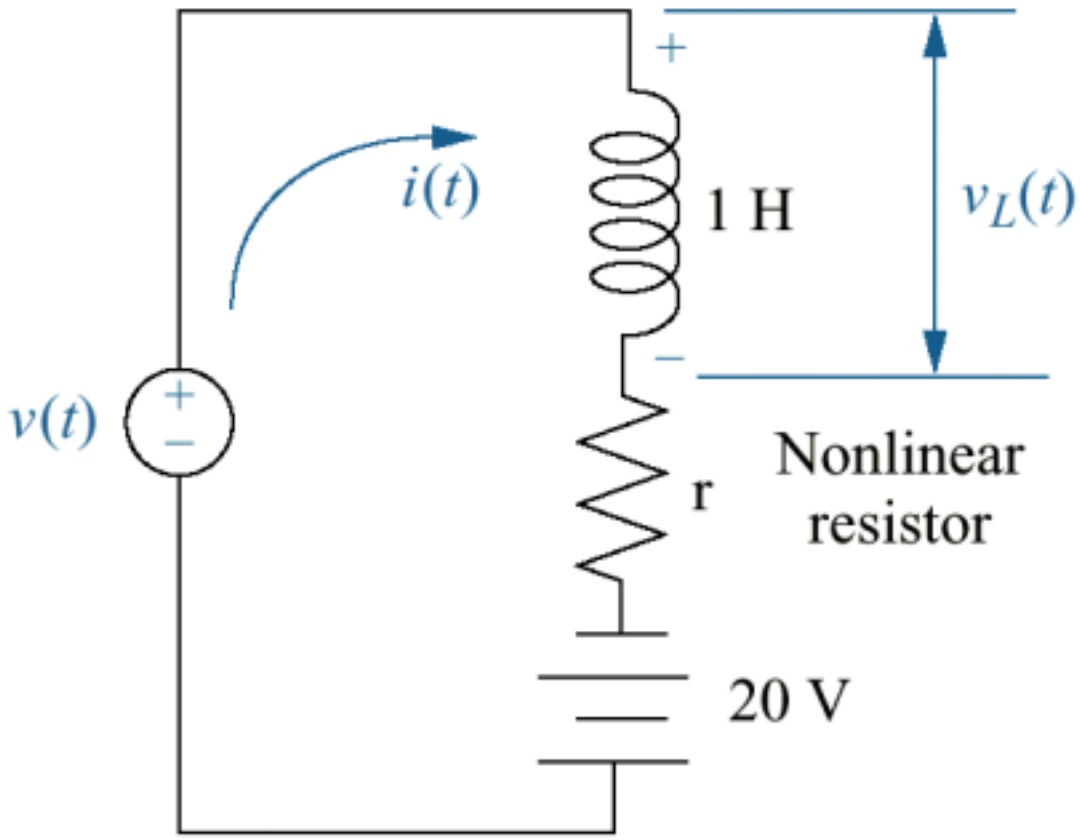


Figure 2.50
Nonlinear electric circuit for Skill-Assessment Exercise 2.13

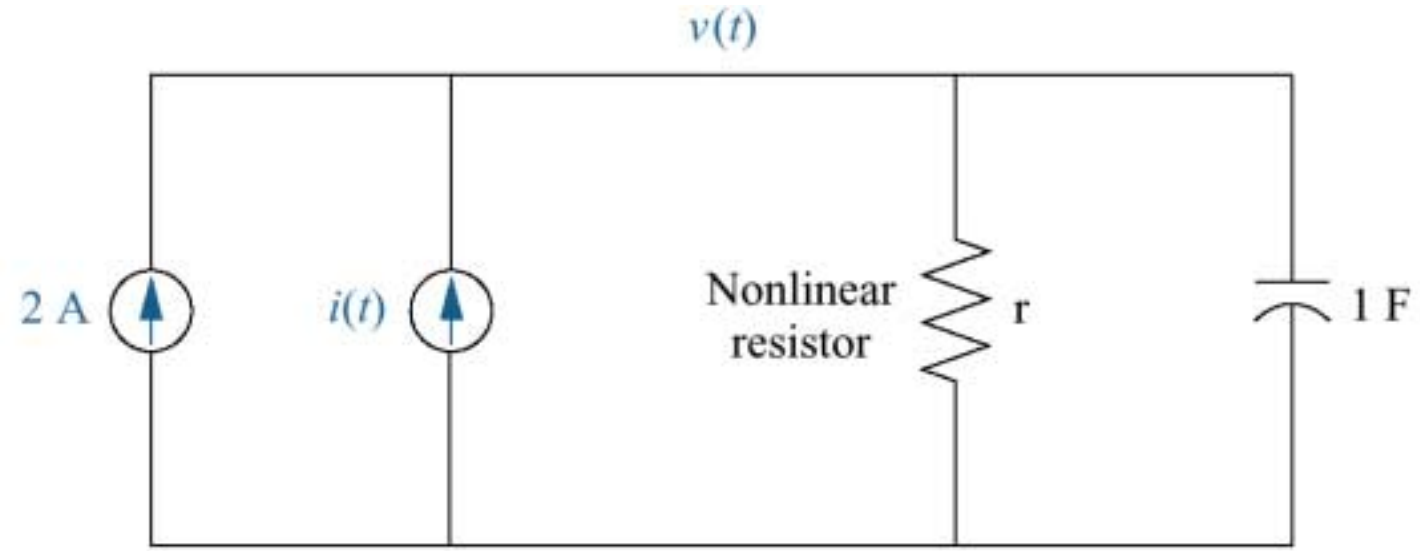


Figure 2.51
Cylinder model of a human leg

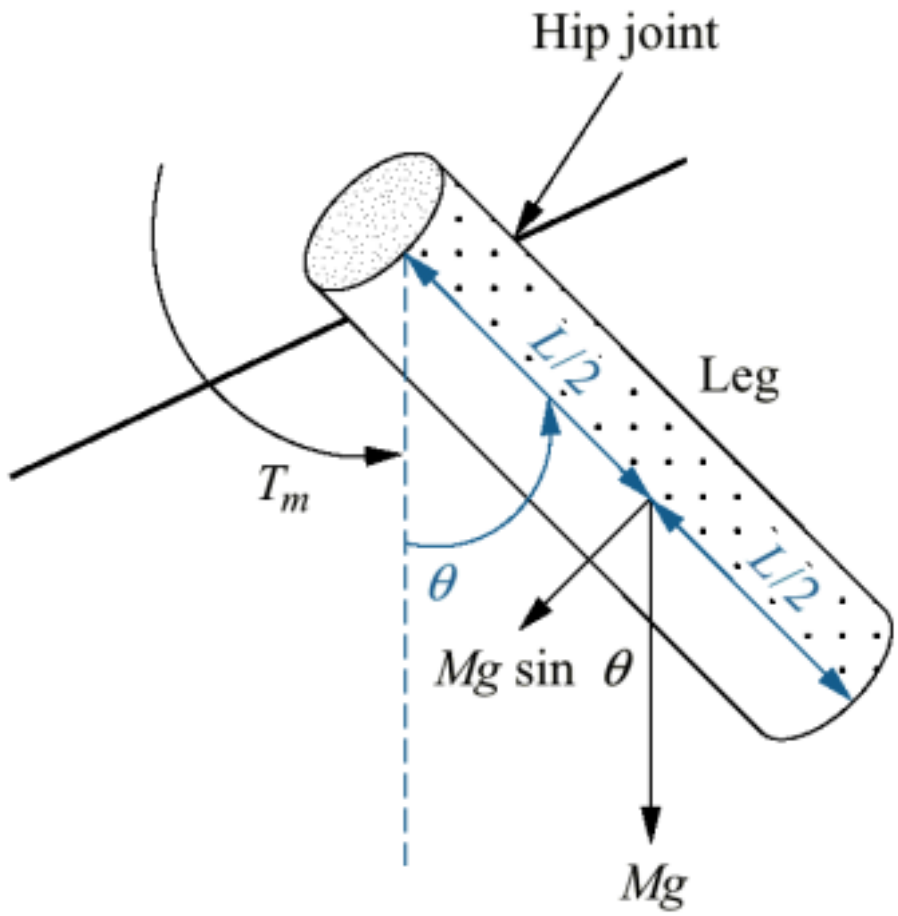


Figure 2.52
Free-body diagram of leg model

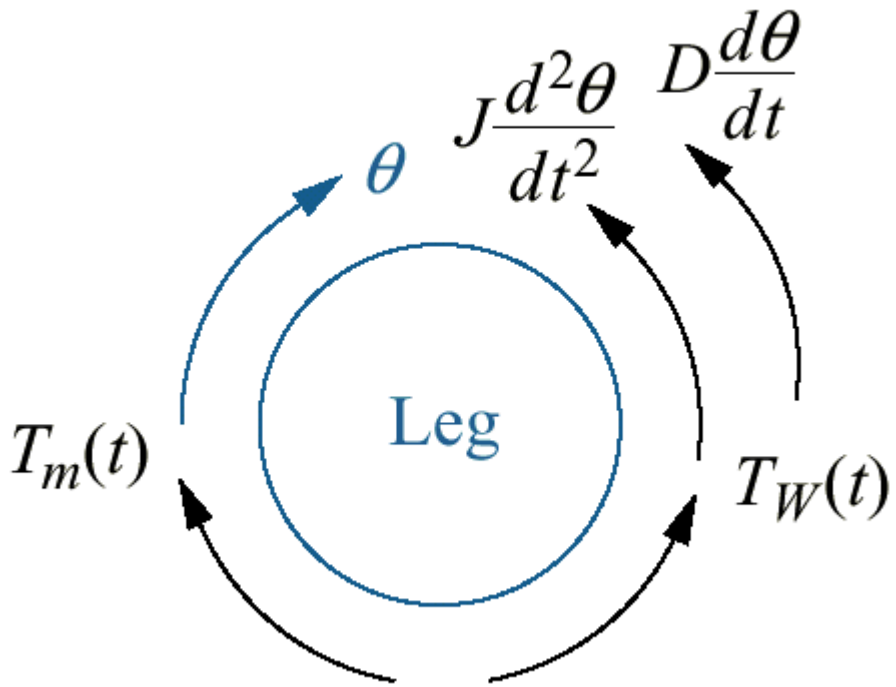


Figure 2.53
Nonlinear electric circuit

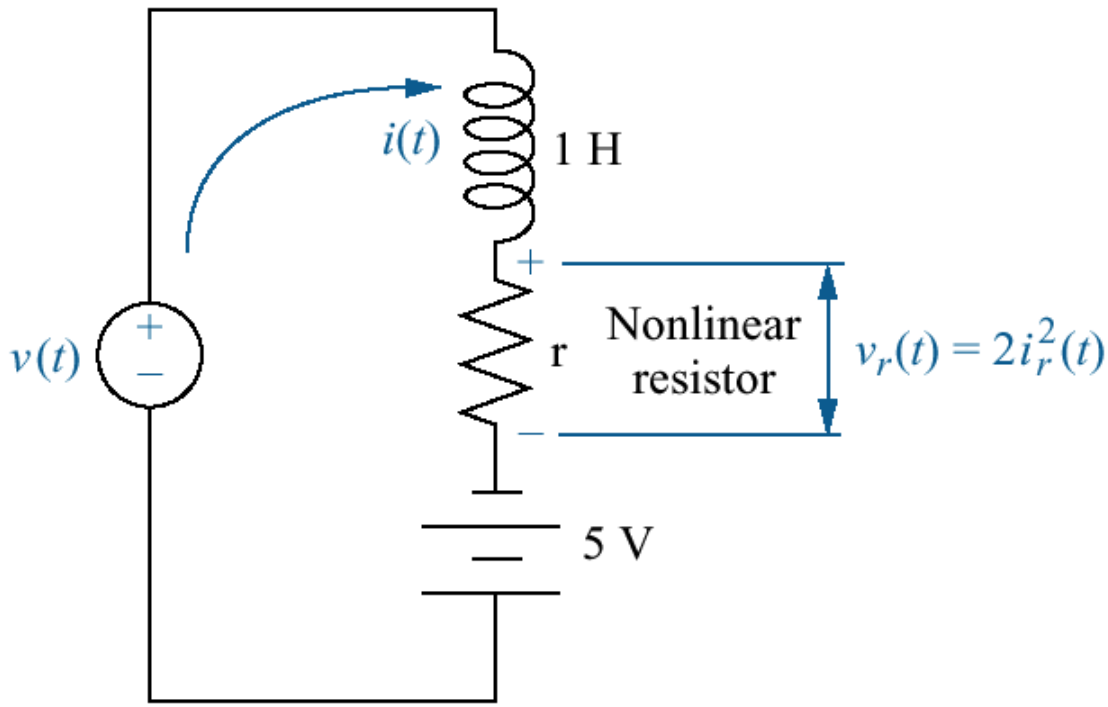


Figure P2.1

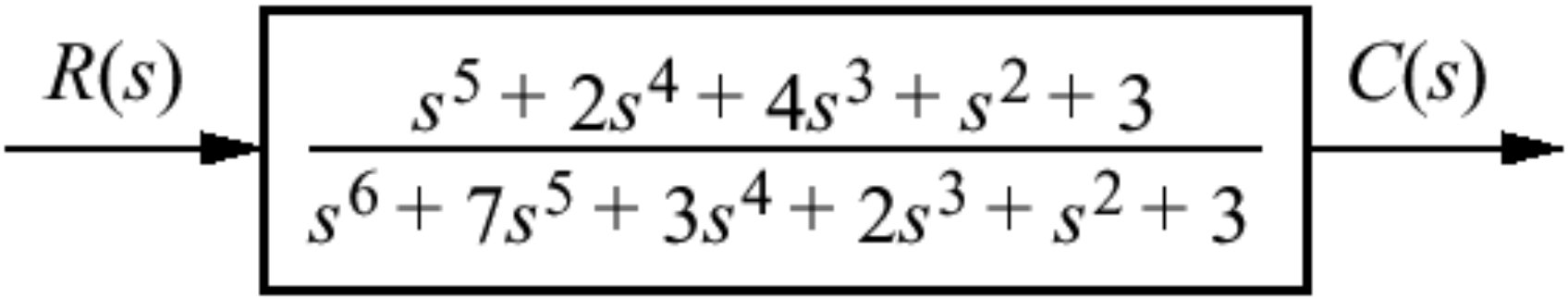


Figure P2.2

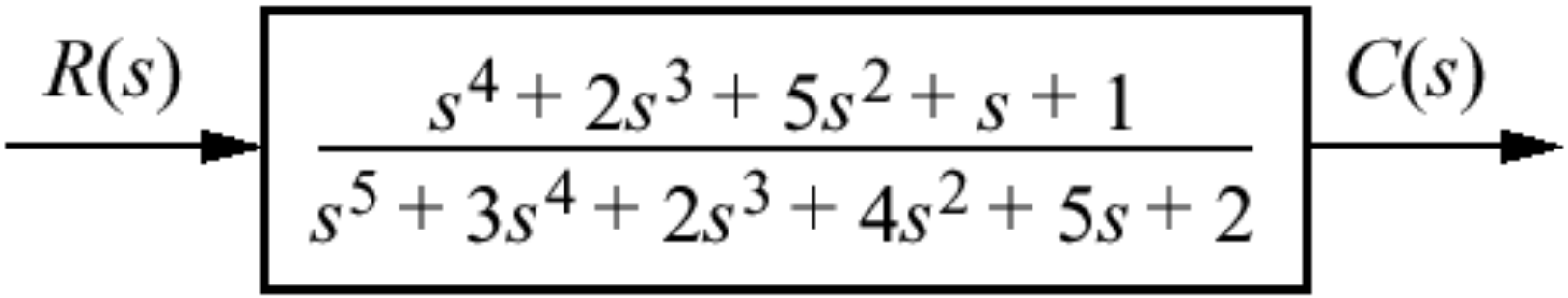


Figure P2.3

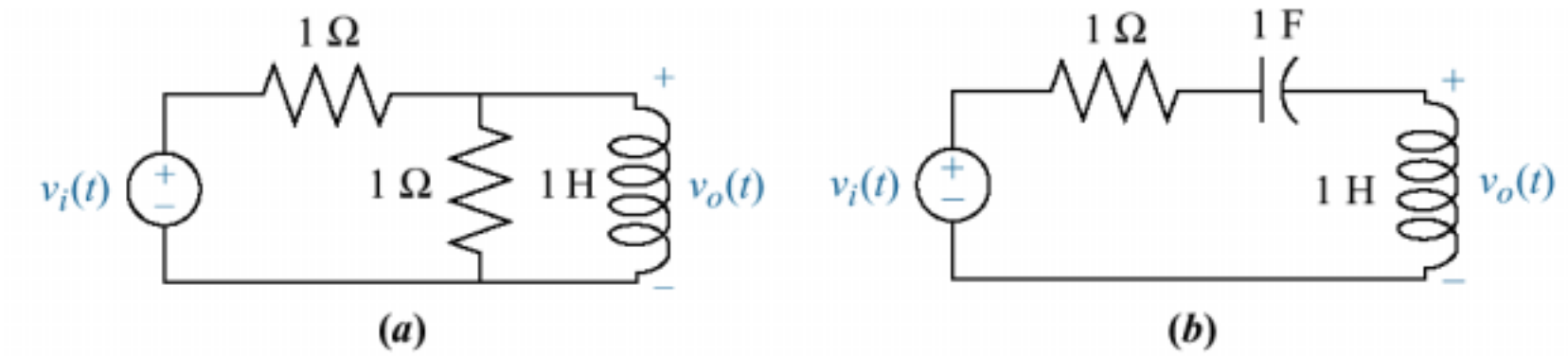


Figure P2.4

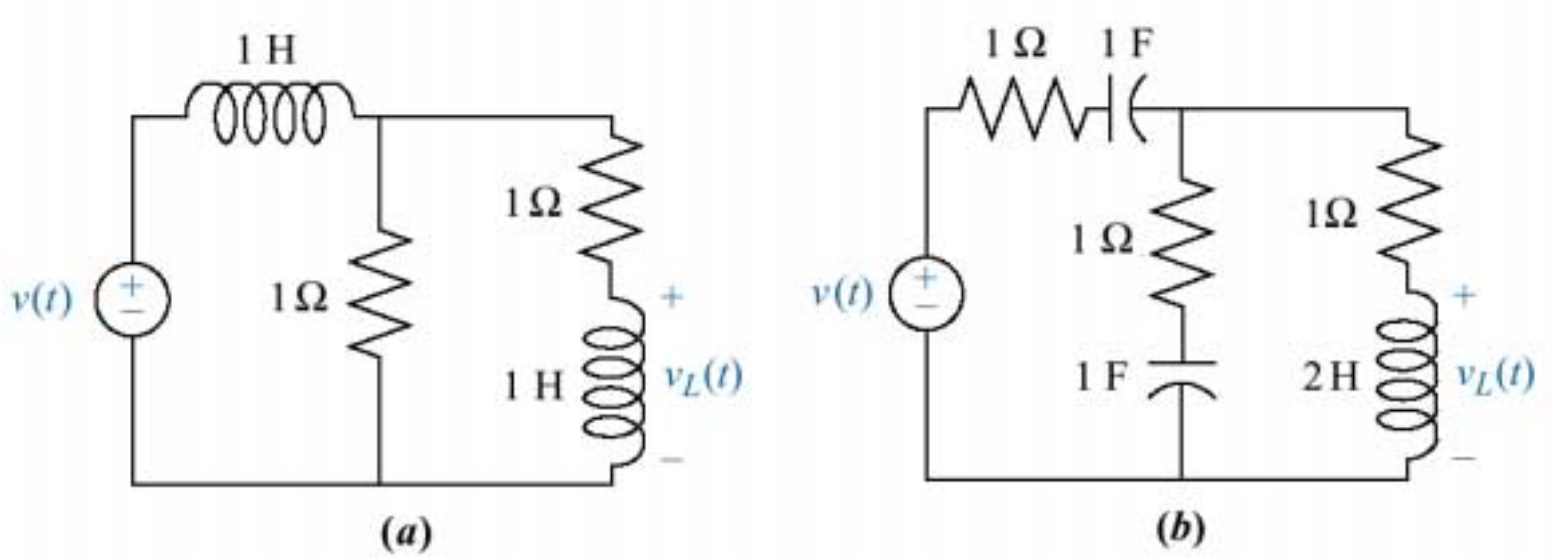


Figure P2.5

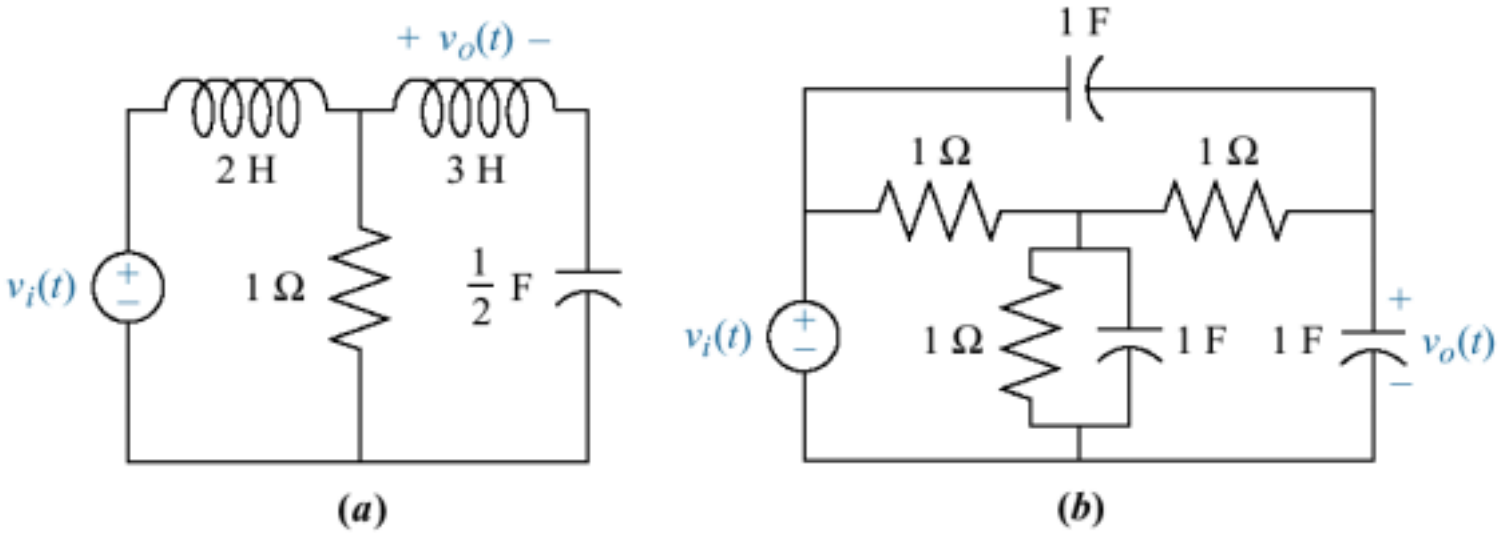


Figure P2.6

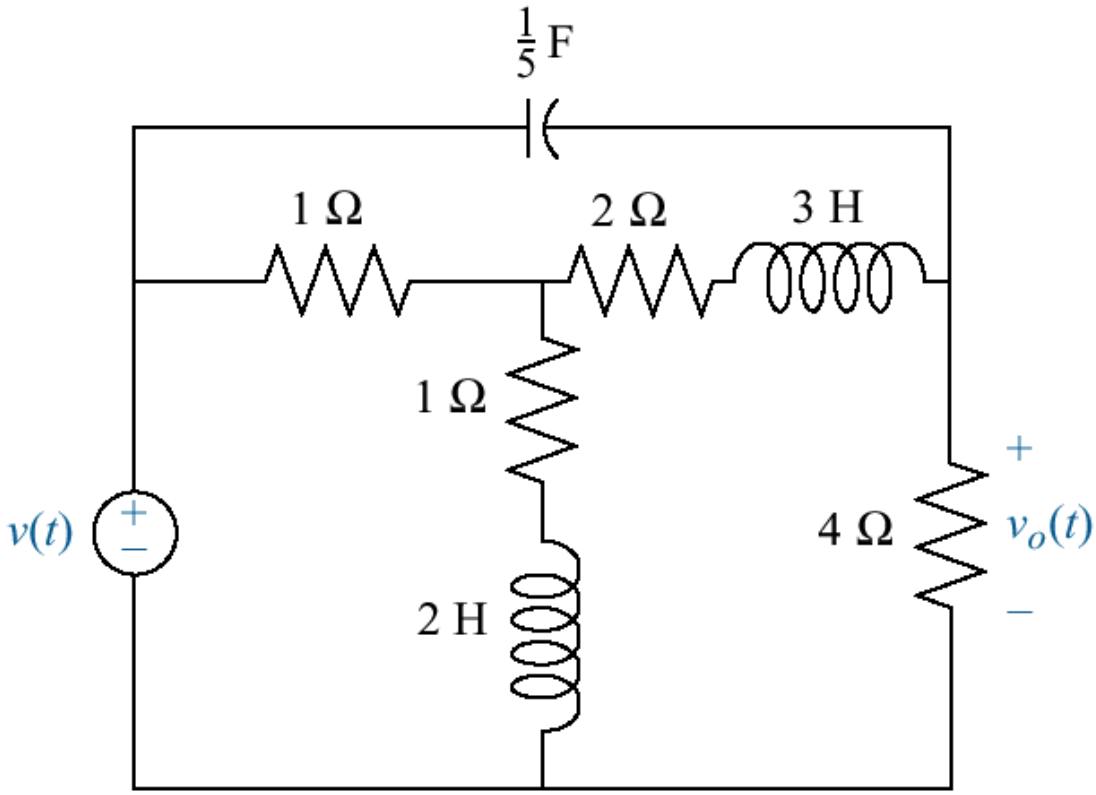


Figure P2.7

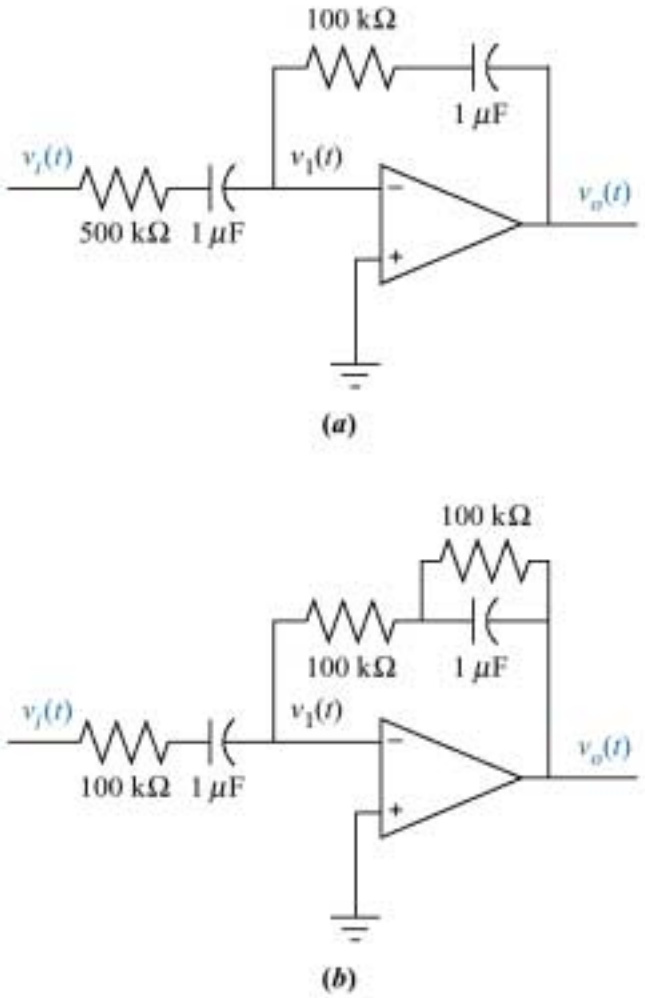


Figure P2.8

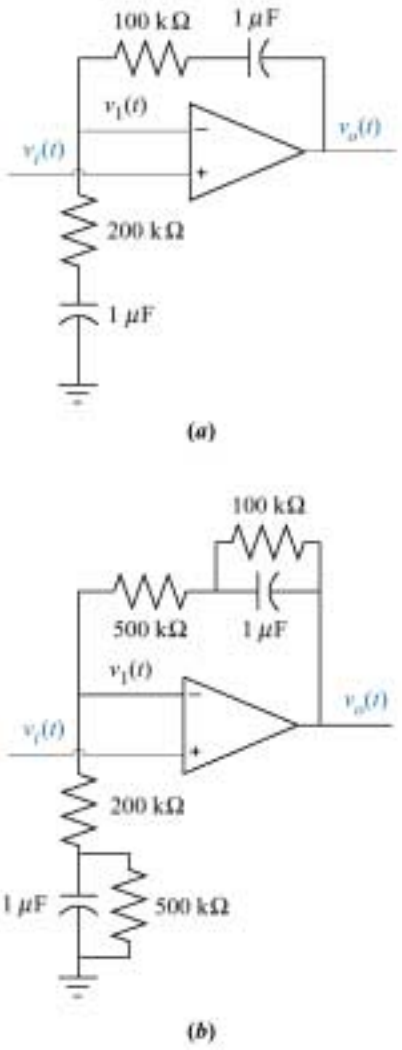


Figure P2.9

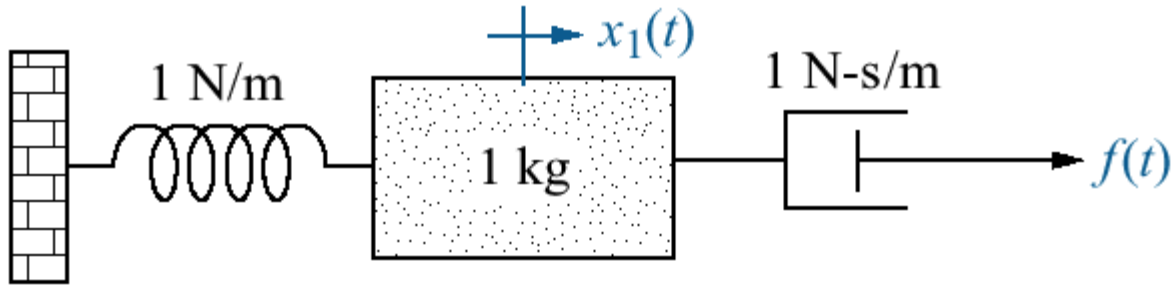


Figure P2.10

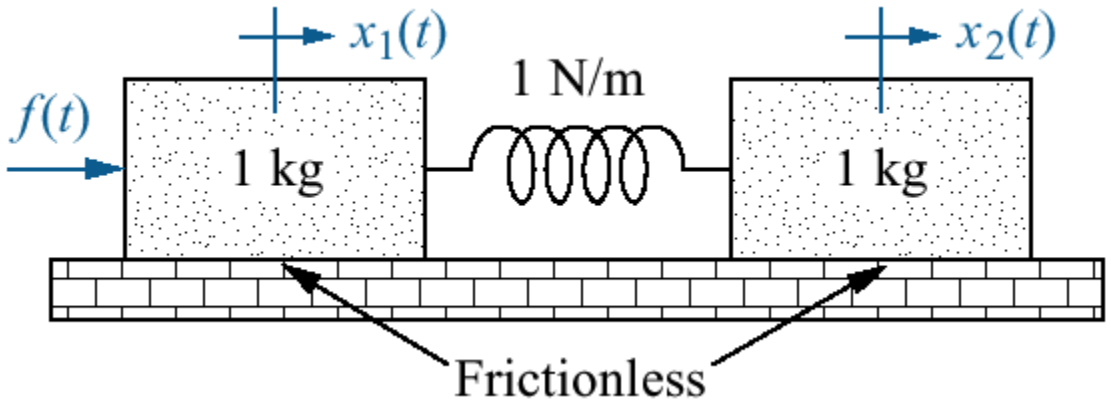


Figure P2.11

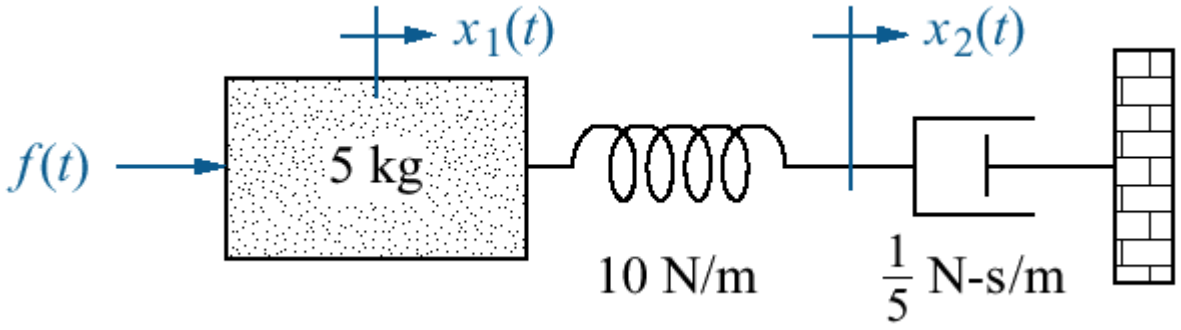


Figure P2.12

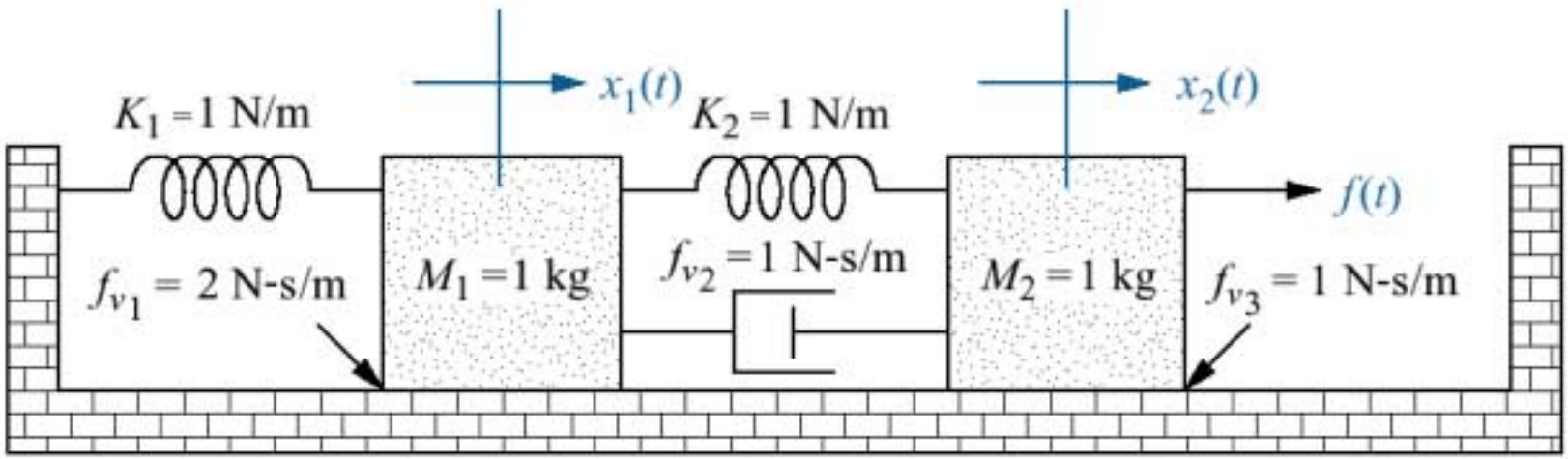


Figure P2.13

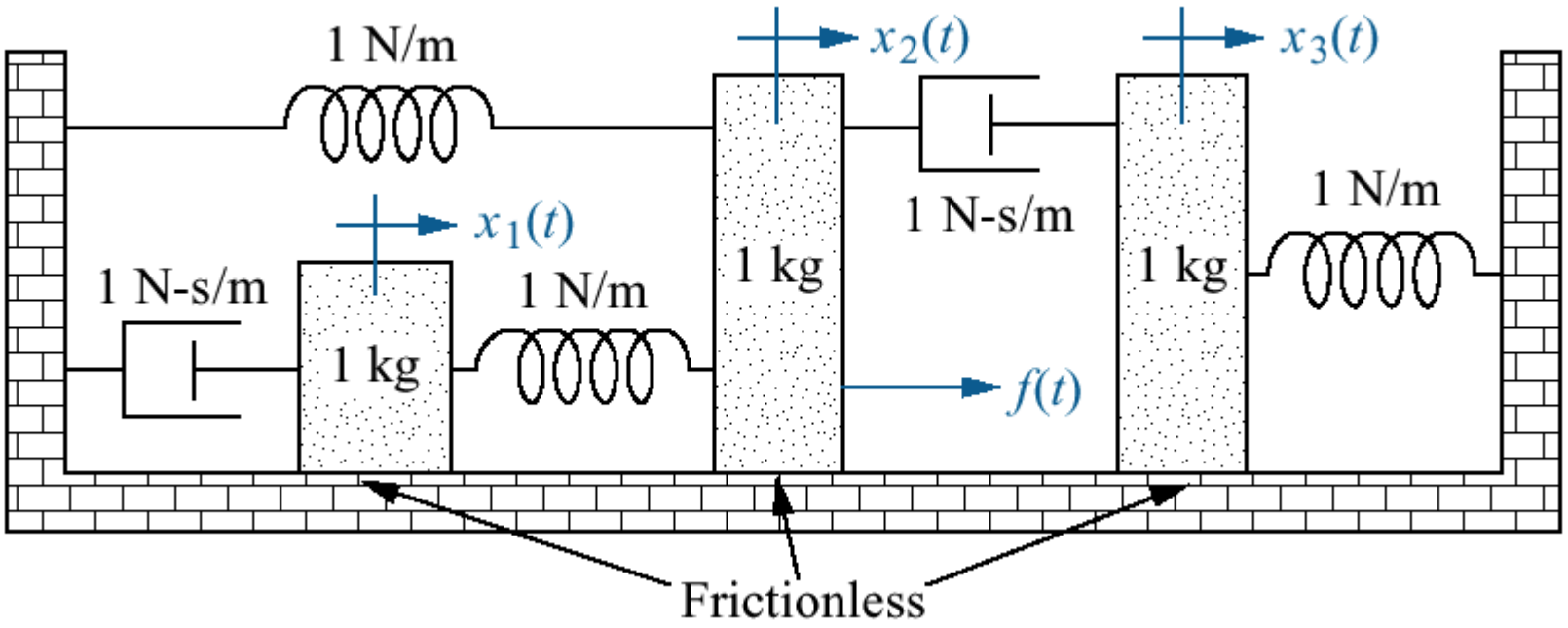


Figure P2.14

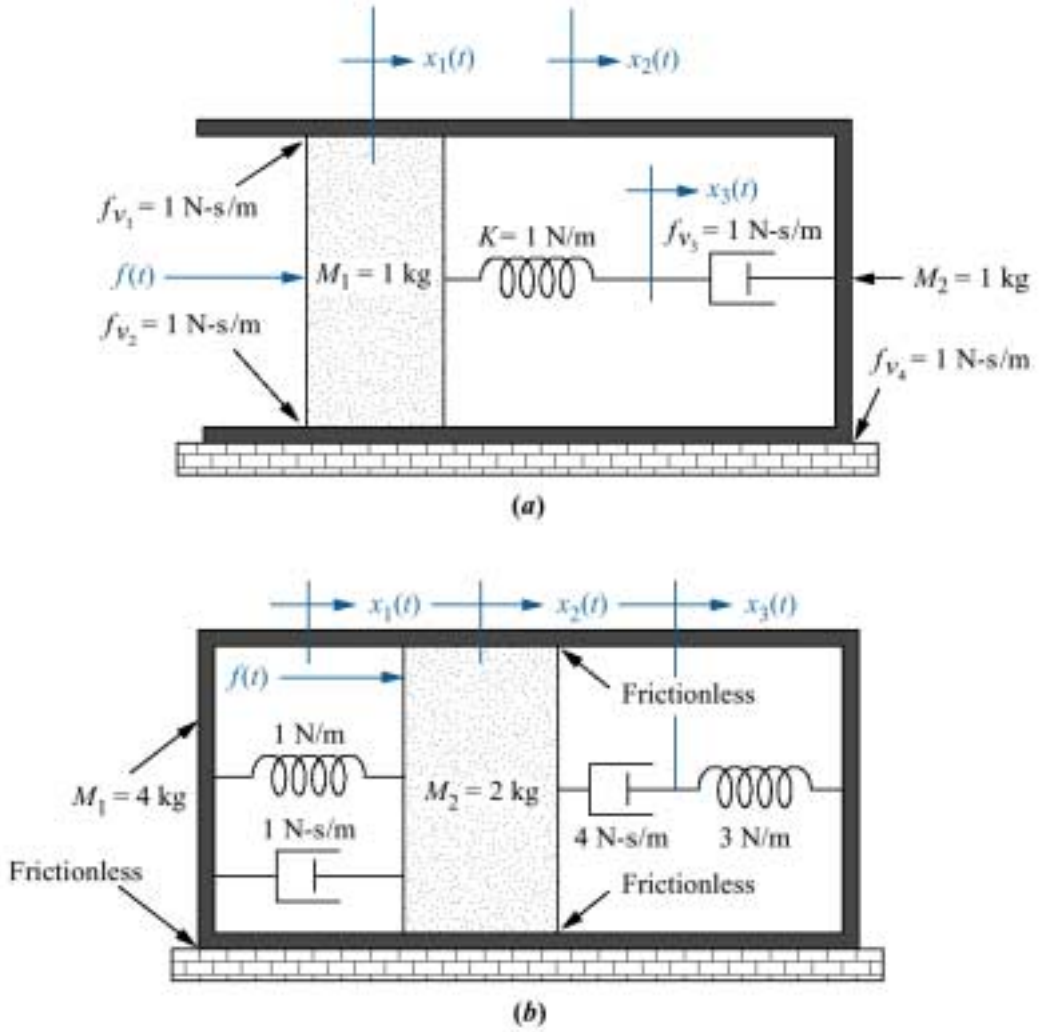


Figure P2.15

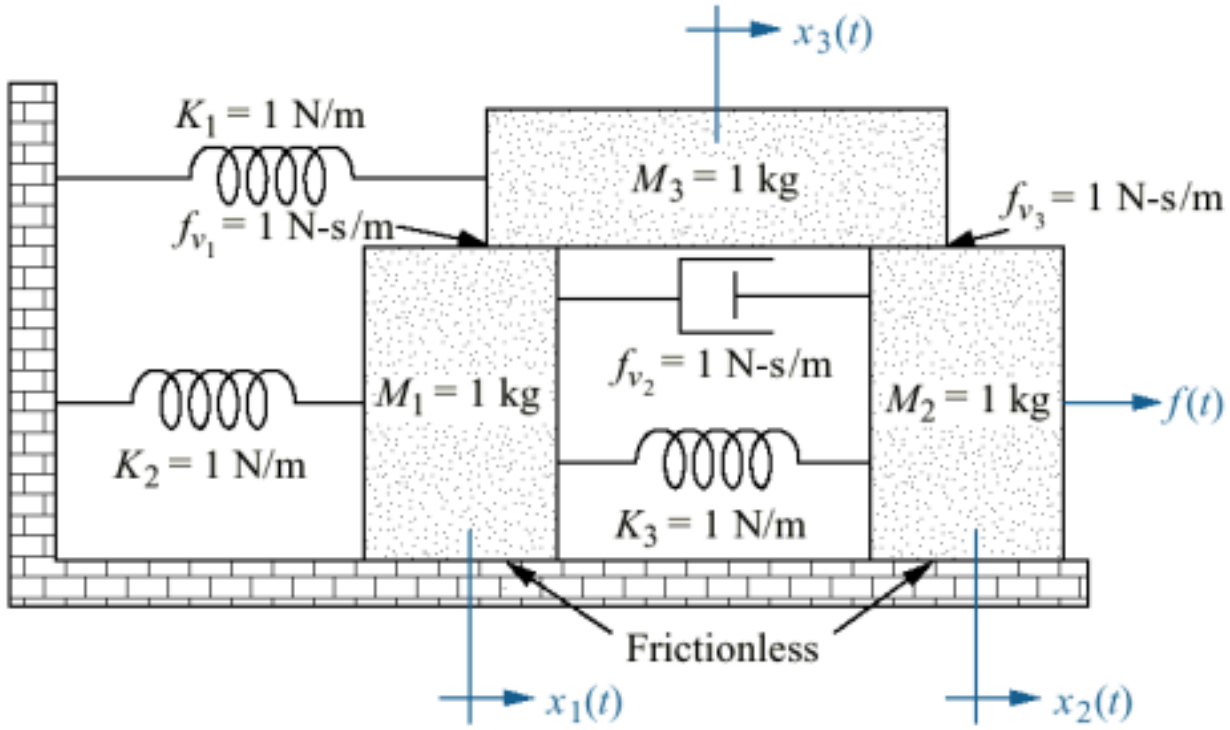


Figure P2.16

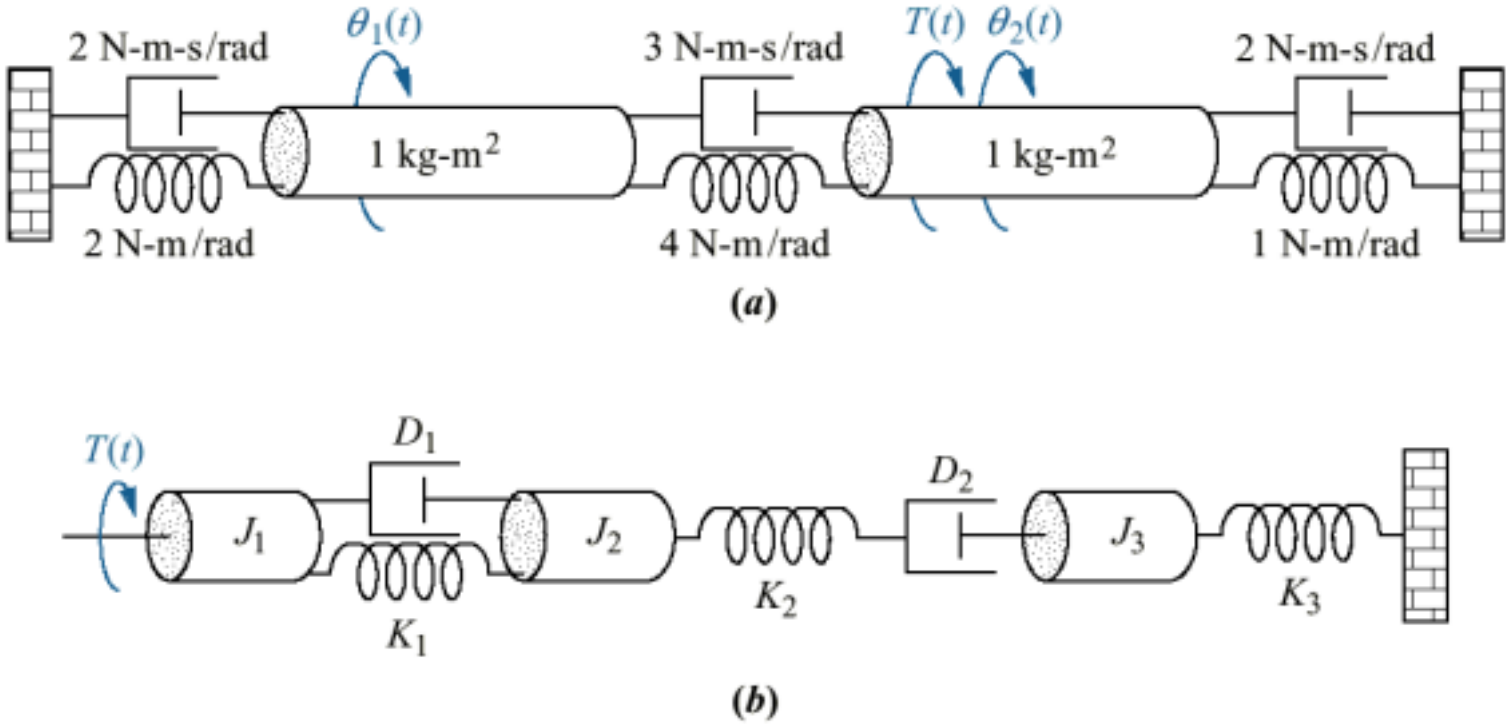


Figure P2.17

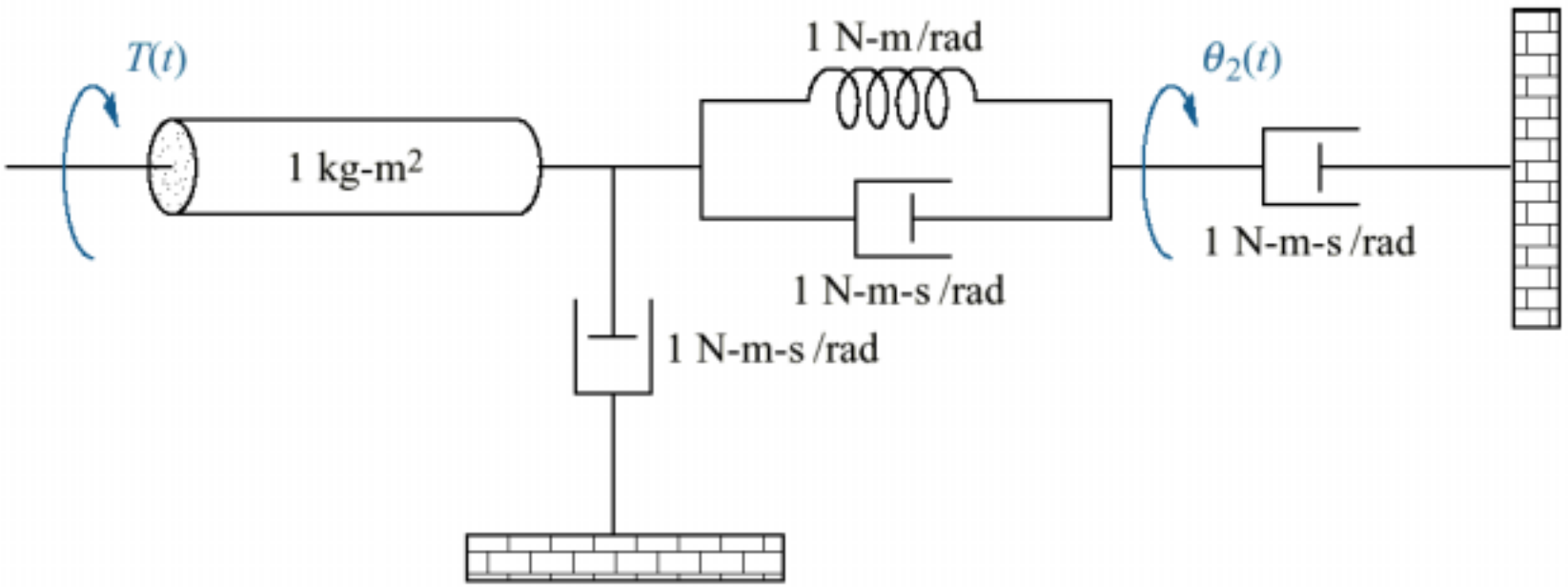


Figure P2.18

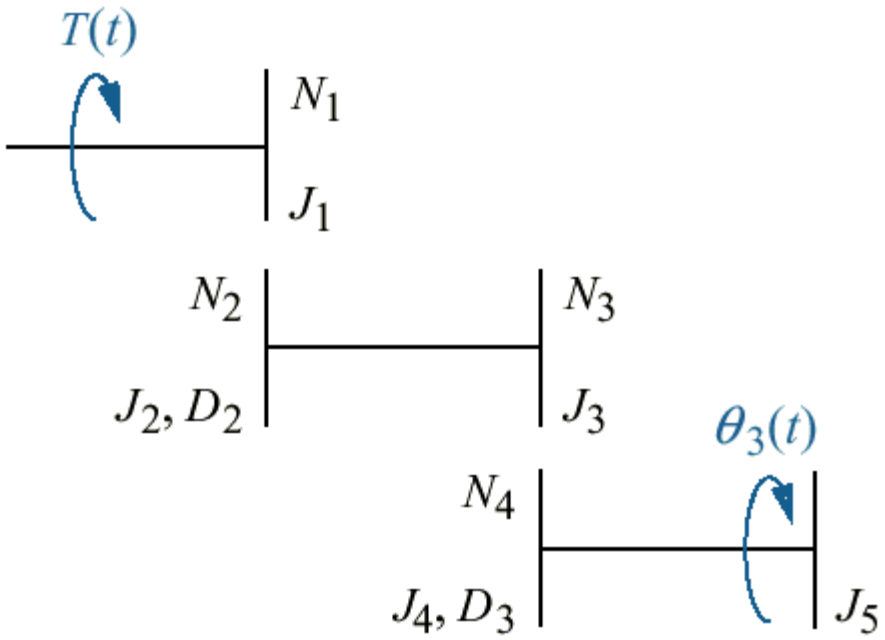


Figure P2.19

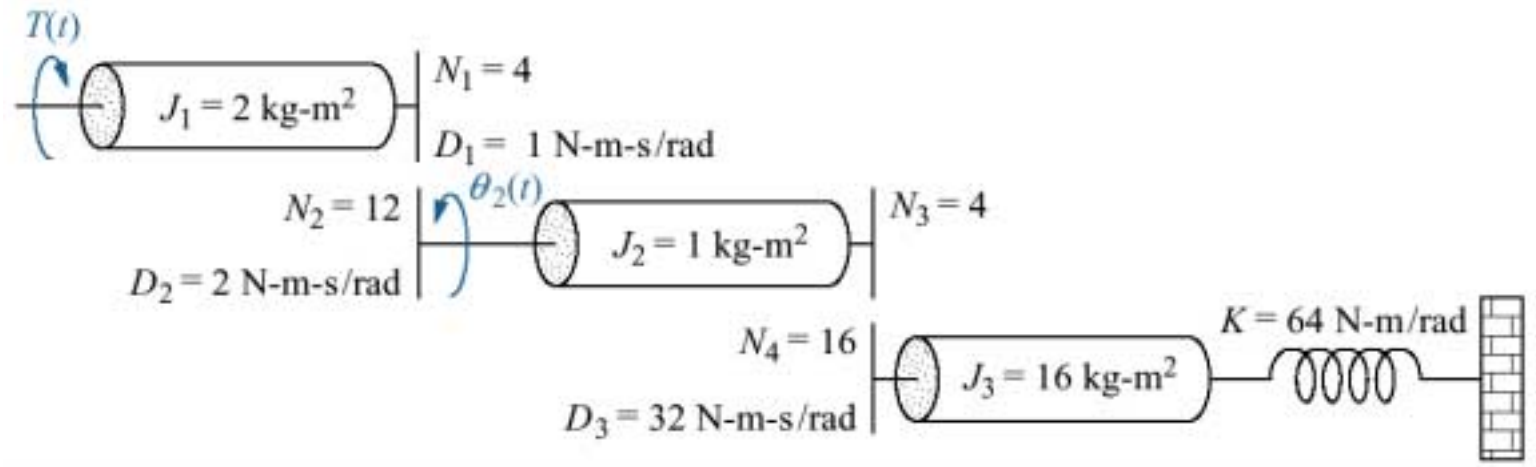


Figure P2.20

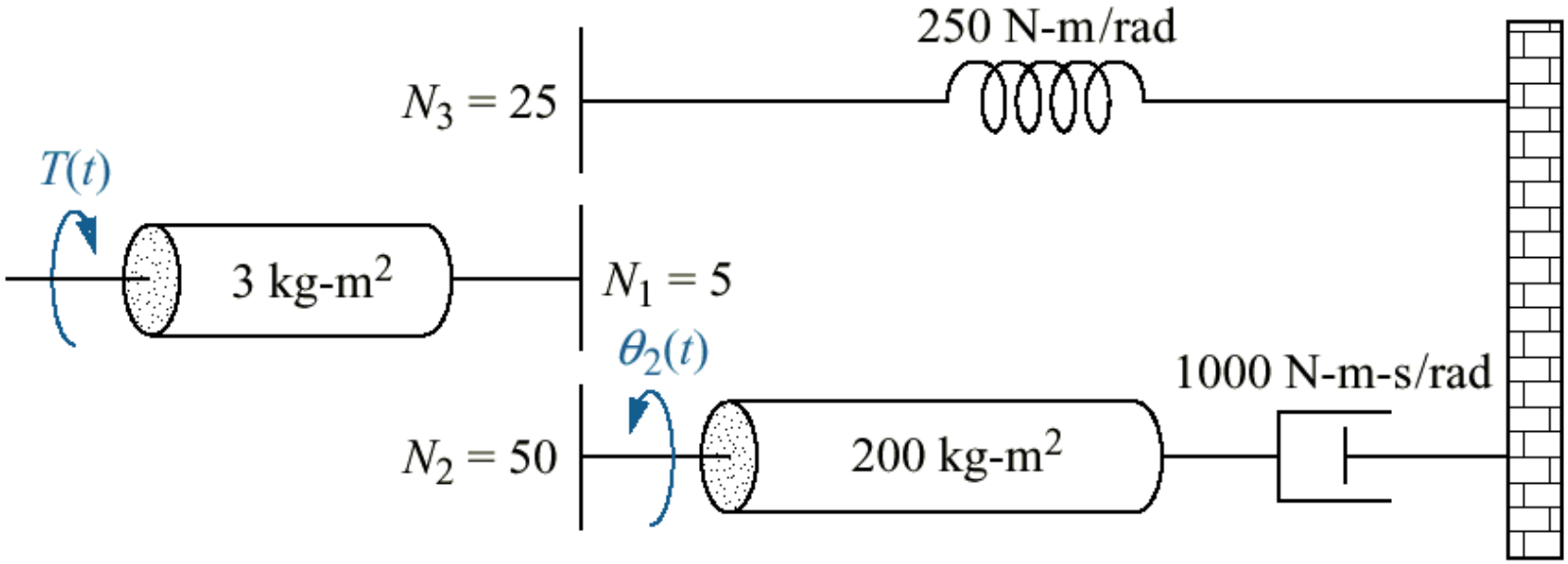


Figure P2.21

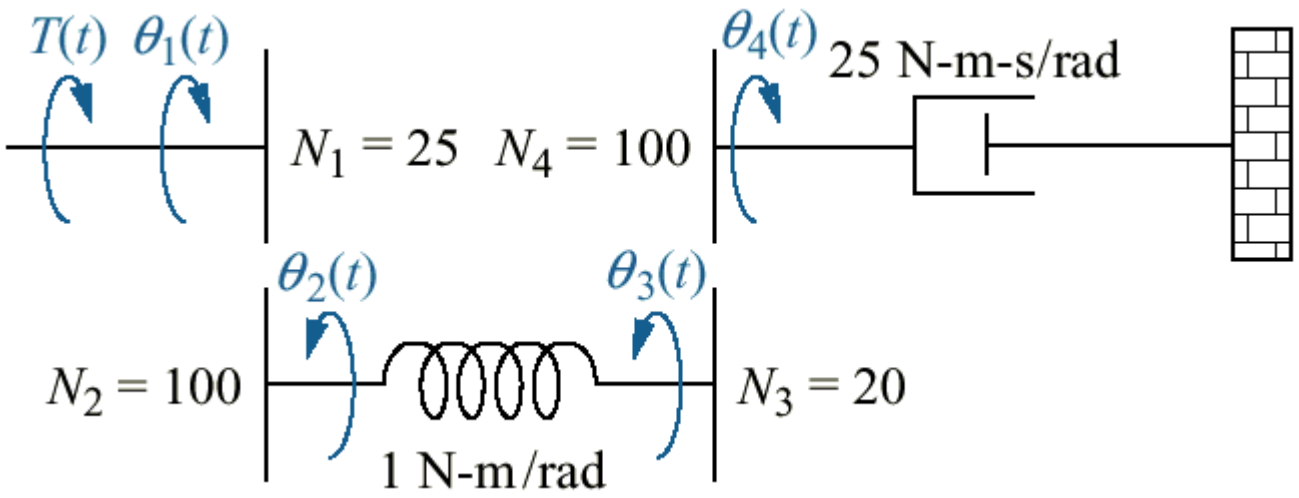


Figure P2.22

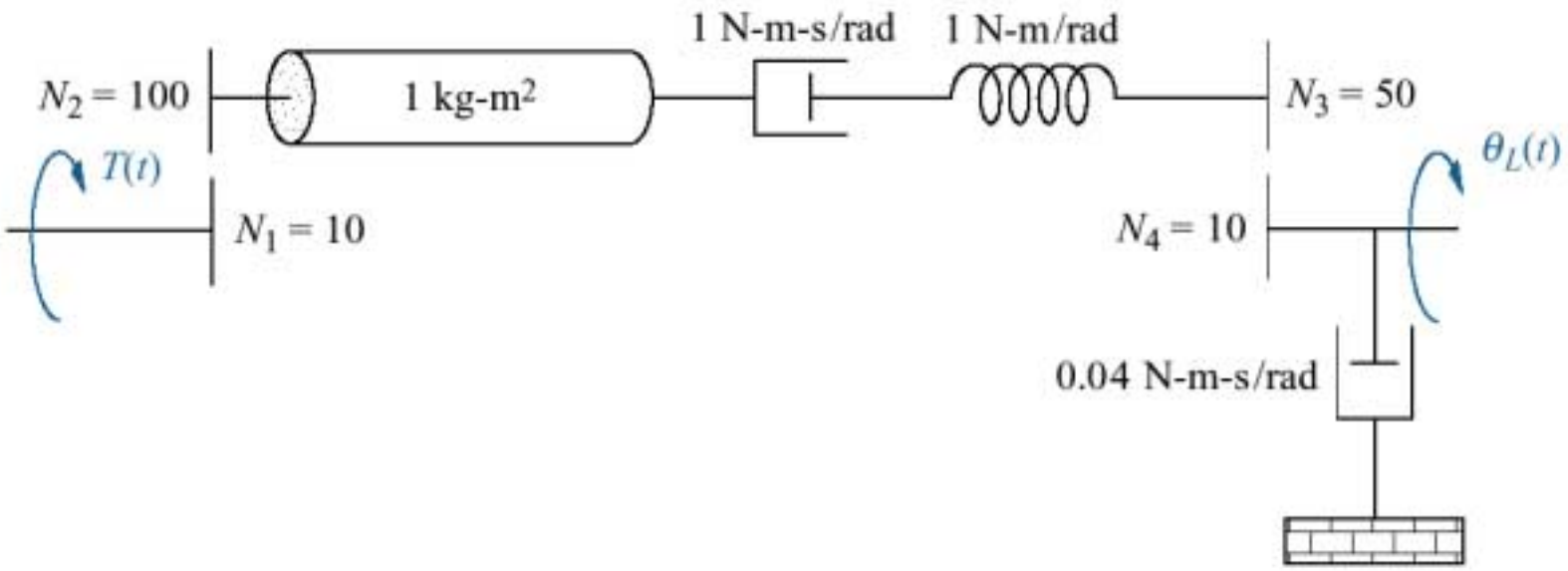


Figure P2.23

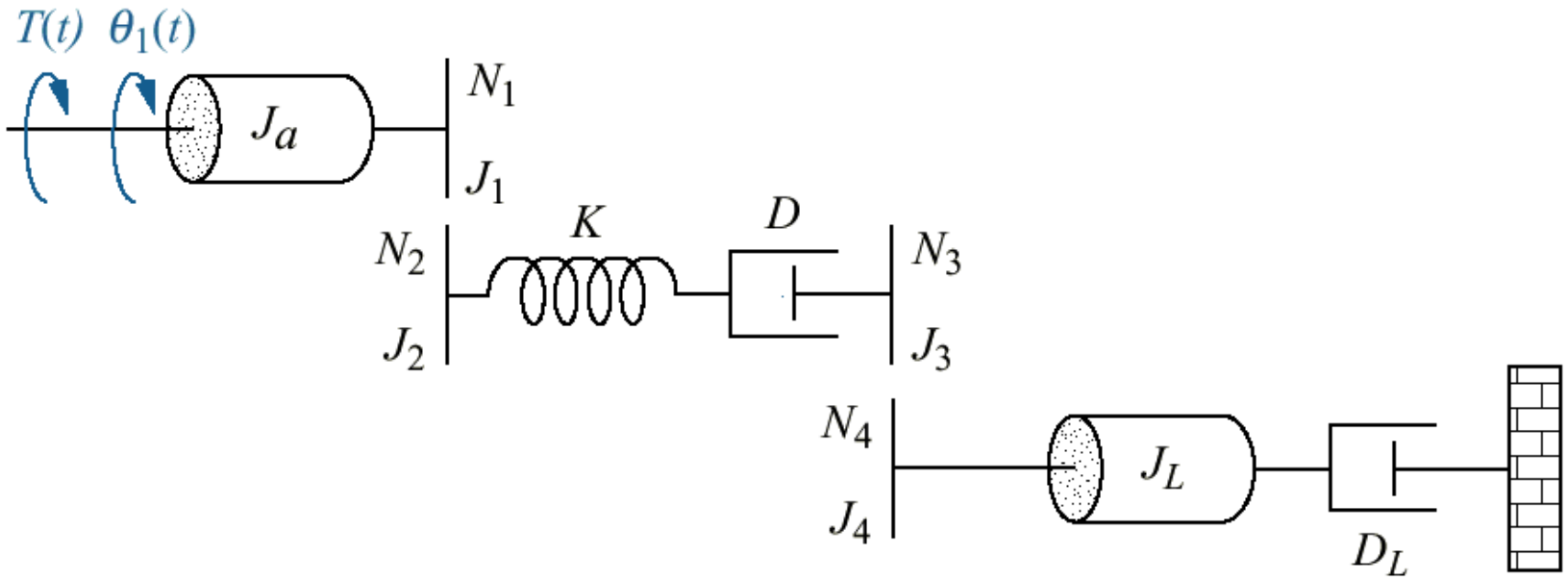


Figure P2.24

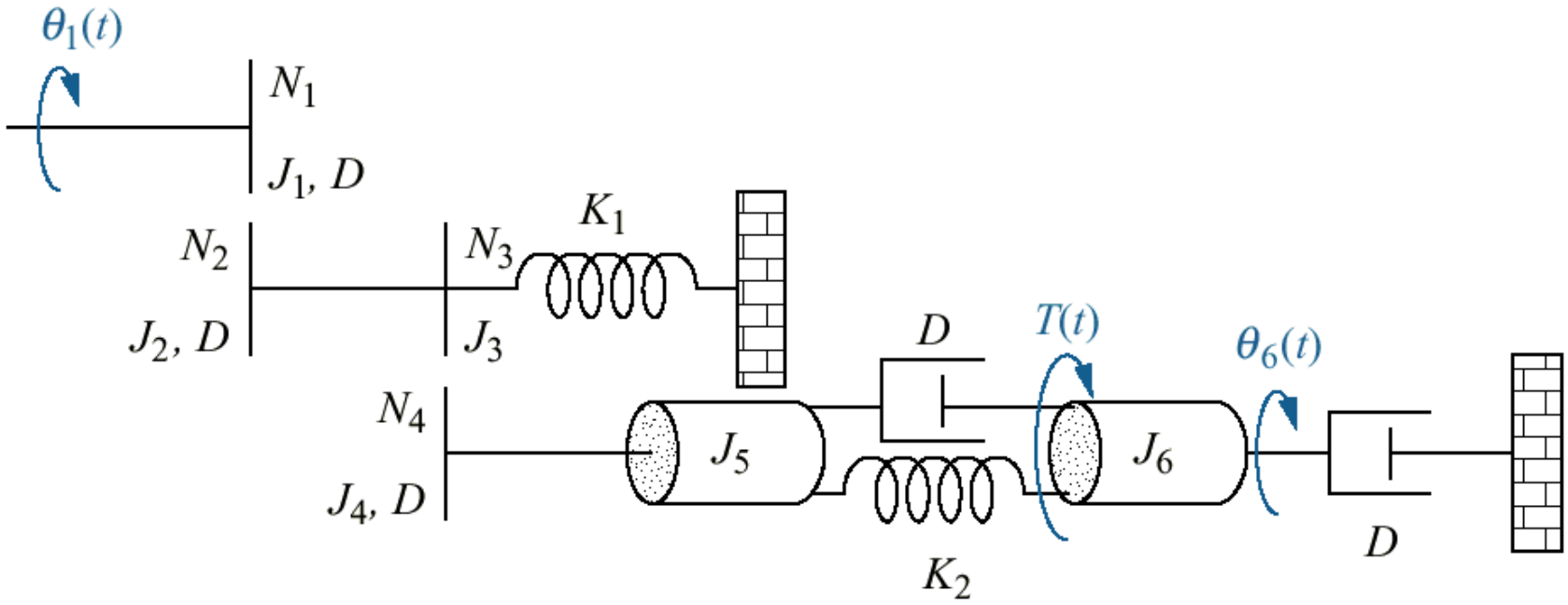


Figure P2.25

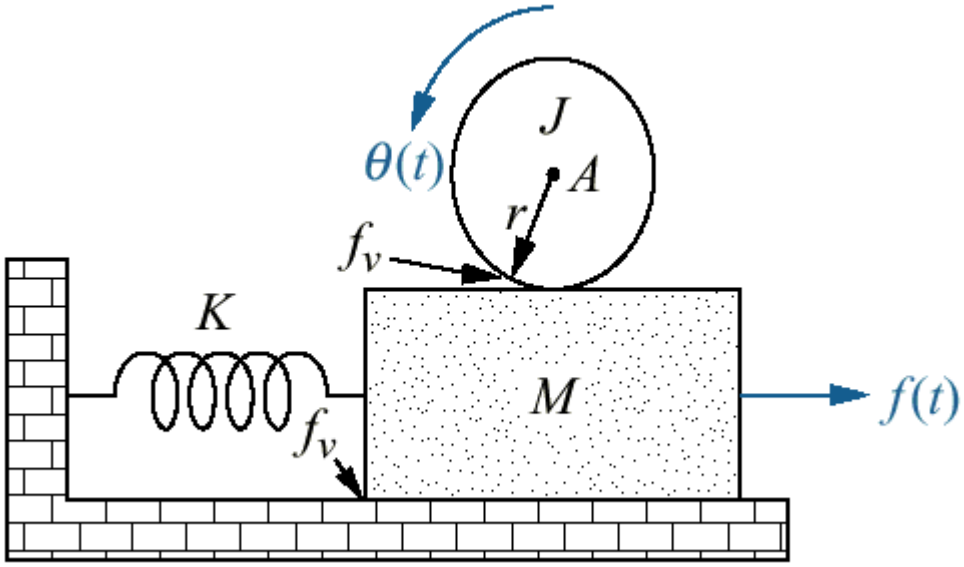


Figure P2.26

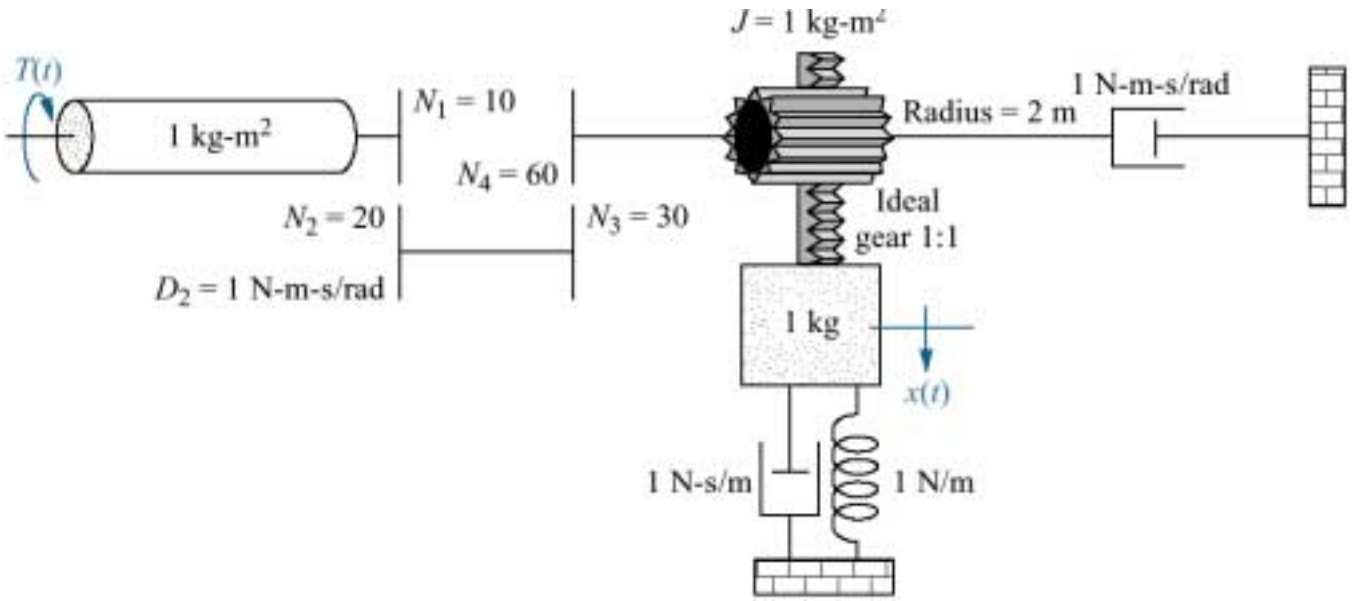


Figure P2.27

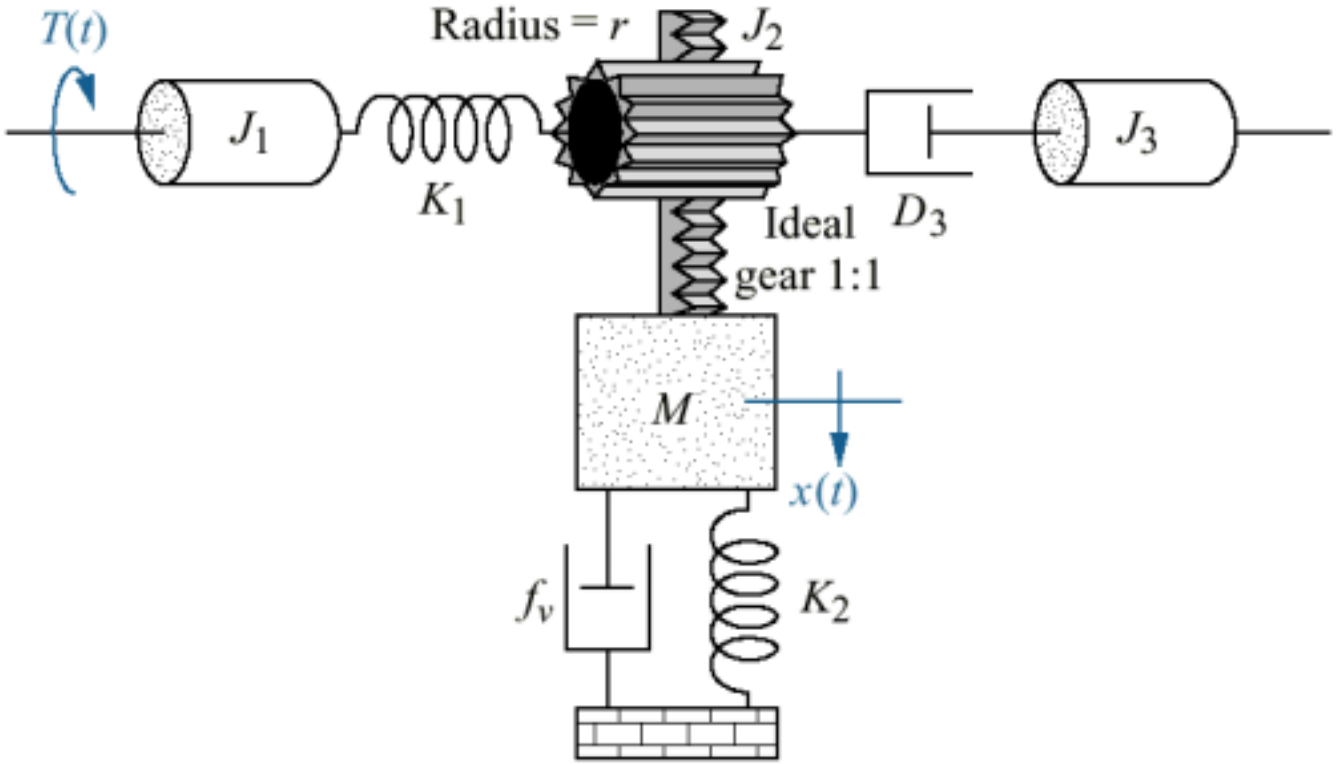
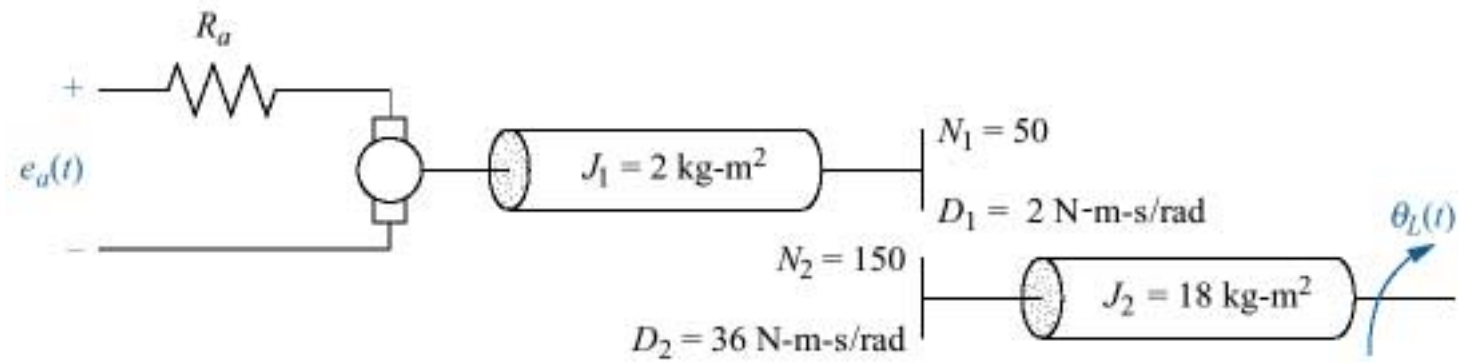


Figure P2.28



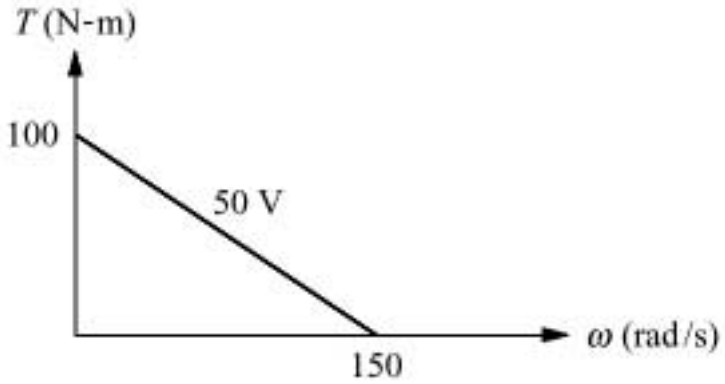


Figure P2.29

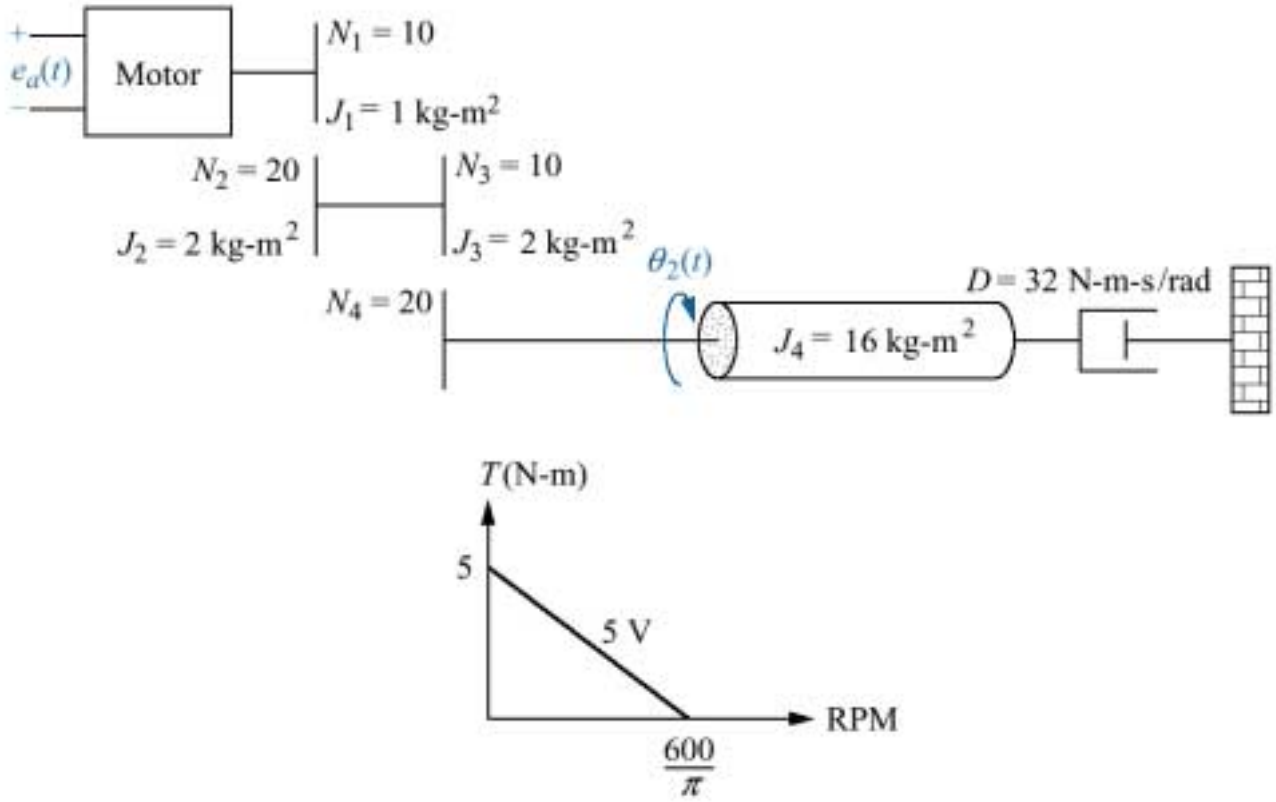


Figure P2.30

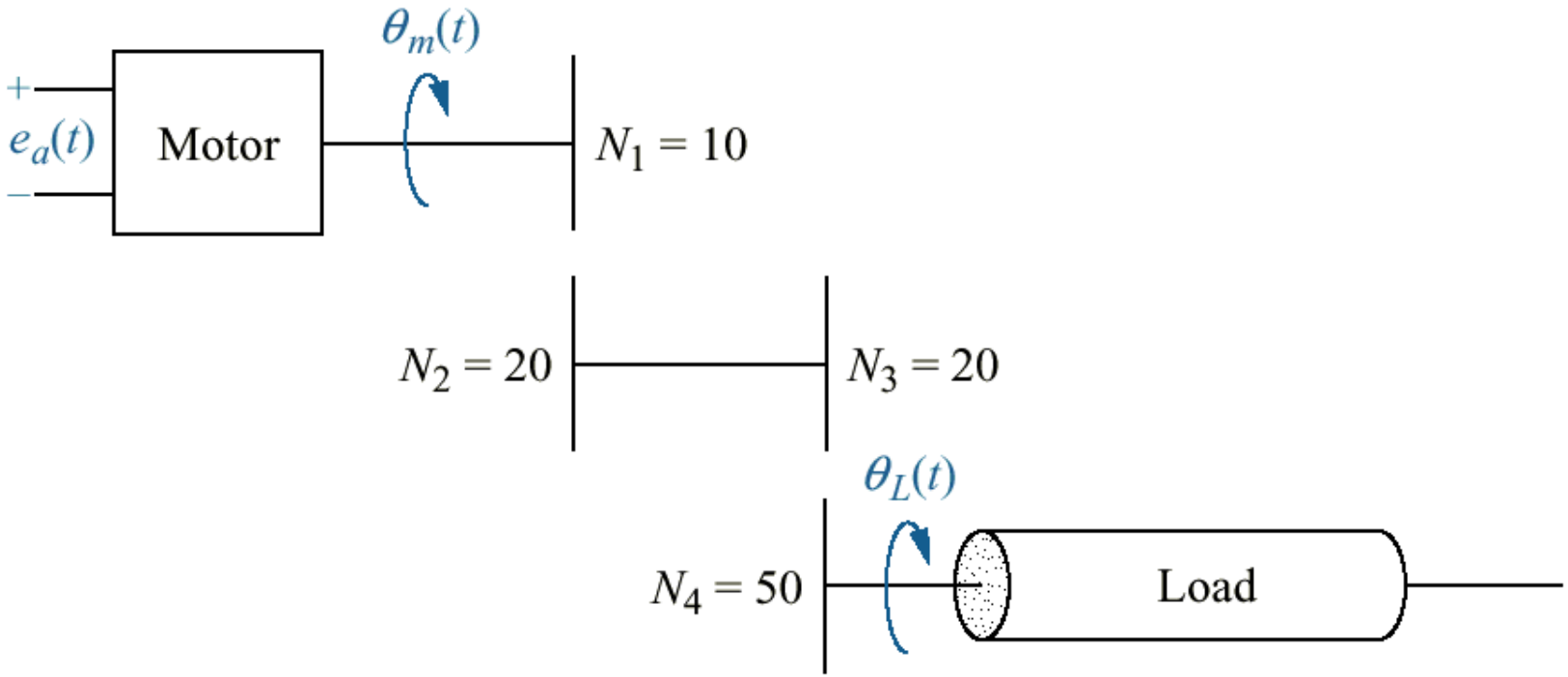


Figure P2.31

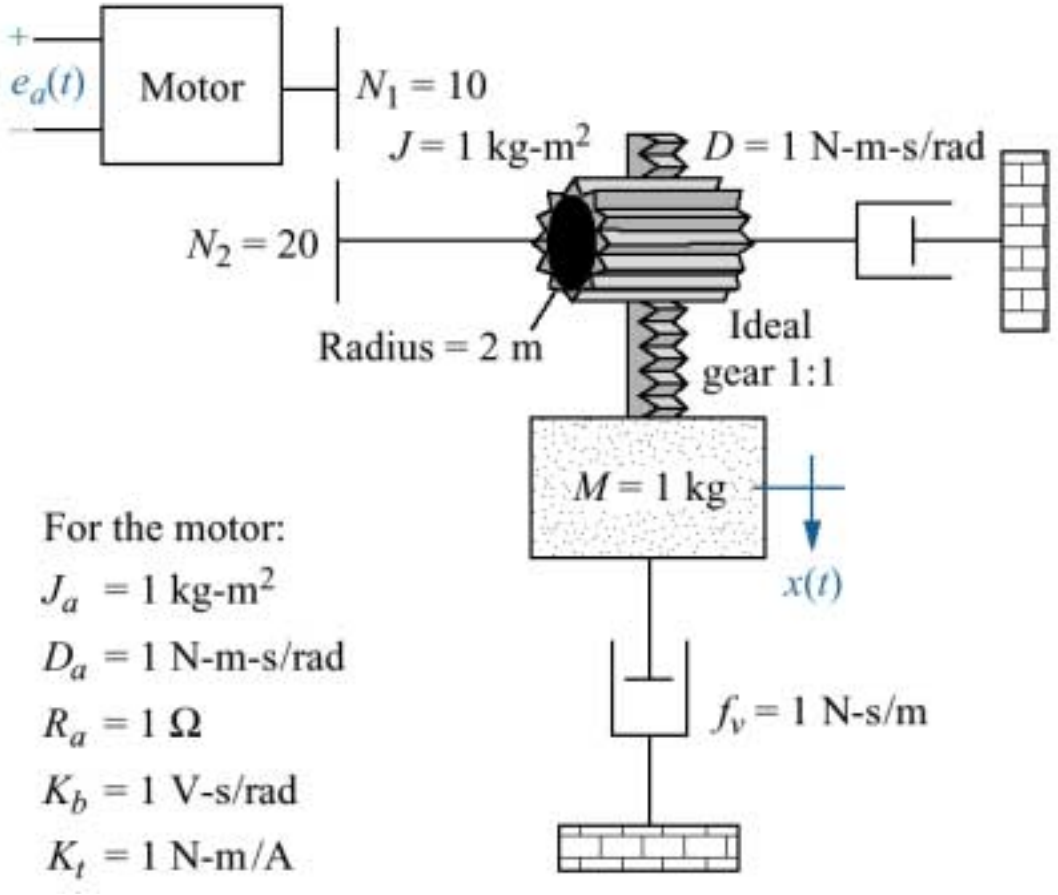


Figure P2.32

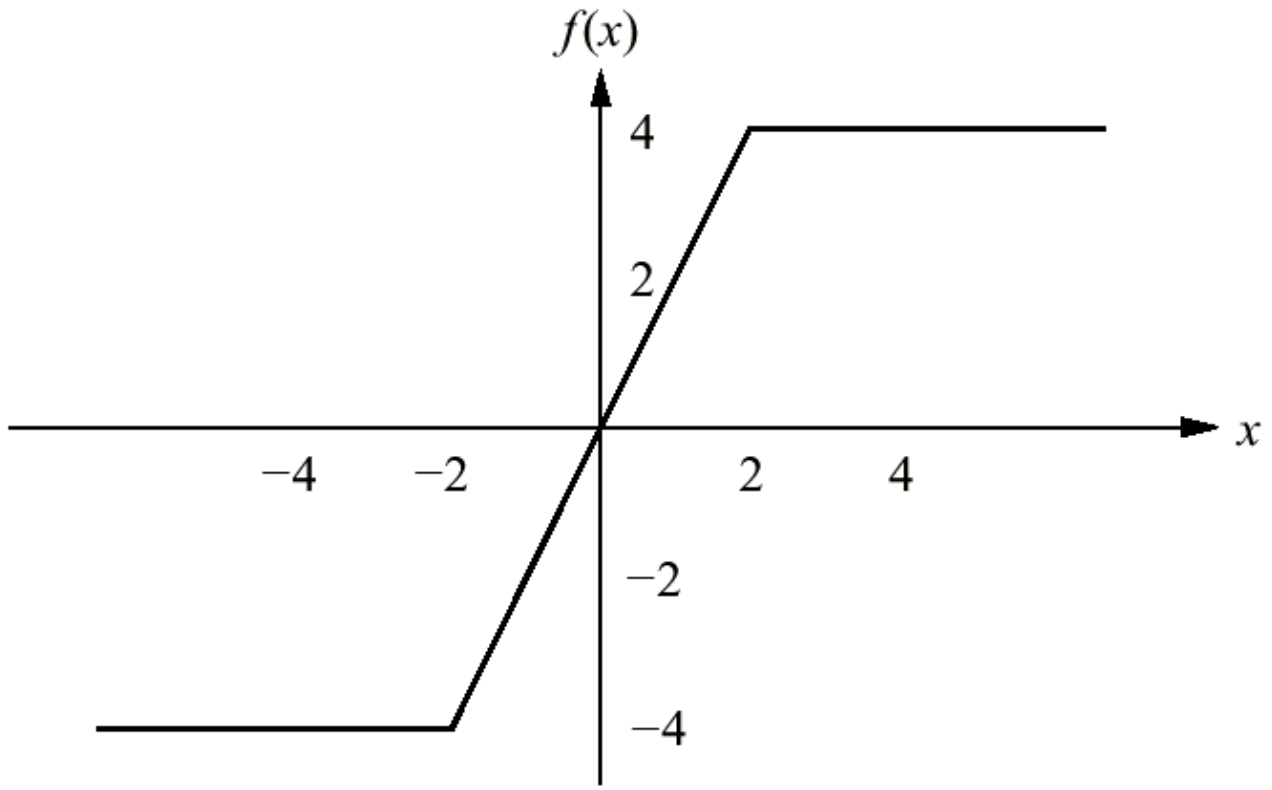


Figure P2.33

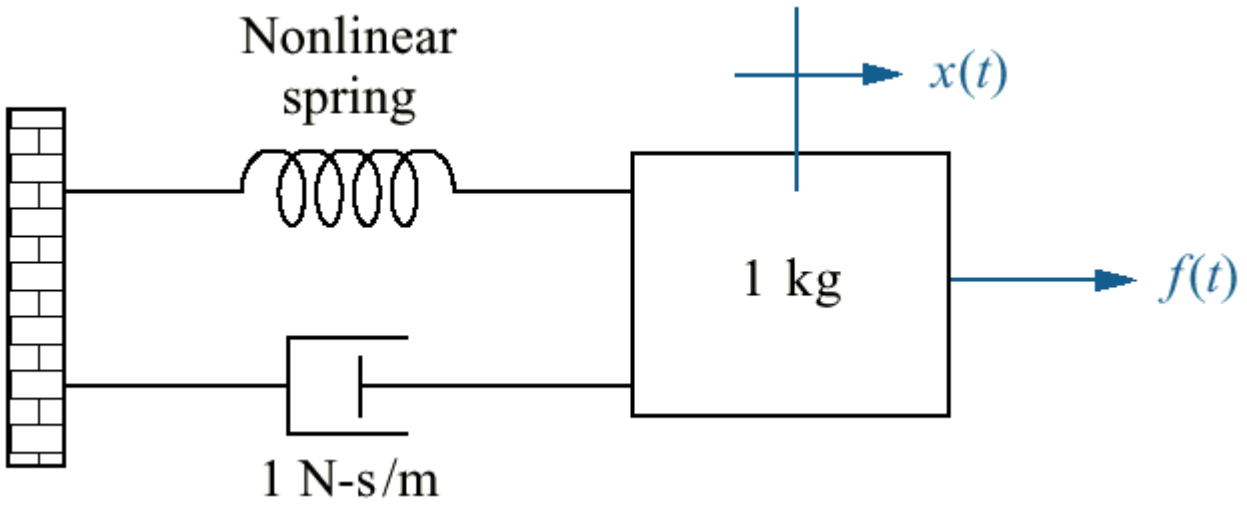


Figure P2.34
Plate dispenser

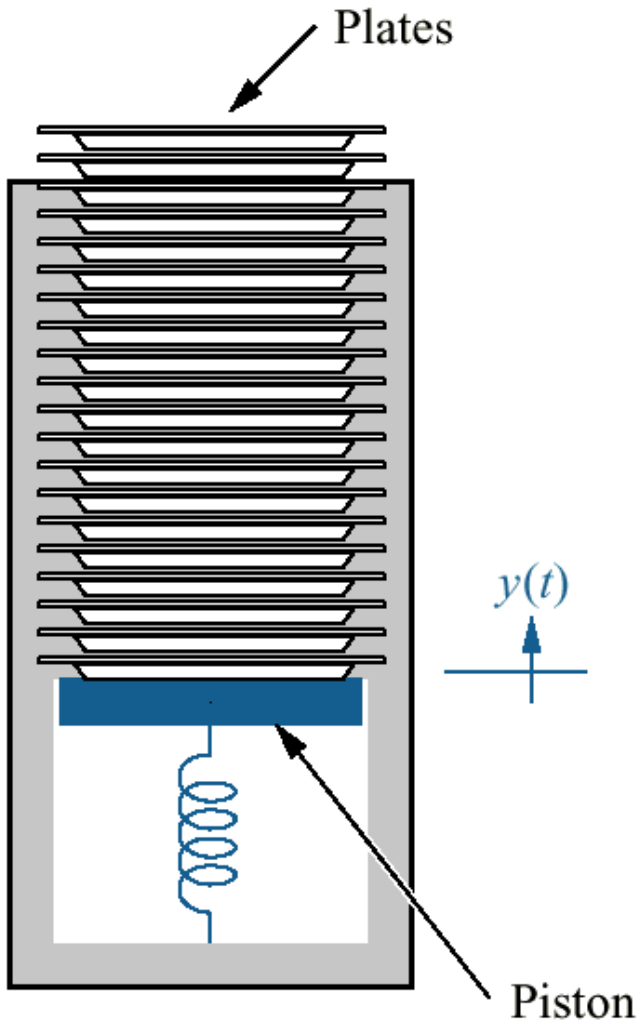


Figure P2.35
a. Coupling of pantograph and catenary;
b. simplified representation showing the active-control force