

# Chapter 1

## P1-1

- (a) The road velocity,  $v_{road}$ , is the input and the mass velocity,  $v_s$ , could be the output.
- (b) The two inputs are the voltage source,  $e(t)$ , and the current source,  $i(t)$ . Potential outputs are the voltage across the capacitor and currents through the inductors.
- (c) The input is the fluid flow,  $Q$ , and potential outputs could be the volumes in each of the accumulator and/or the flow out of the system.

## P1-2

$$\tau = rF = rma = rm\dot{v} = rm\frac{d}{dt}(\omega r) = mr^2\dot{\omega} = J\dot{\omega}$$

## P1-3

The constitutive relation for the spring is

$$F_s = kx(t)$$

and the constitutive relations for the inductor and resistor are

$$i_L = \frac{\lambda}{L}$$

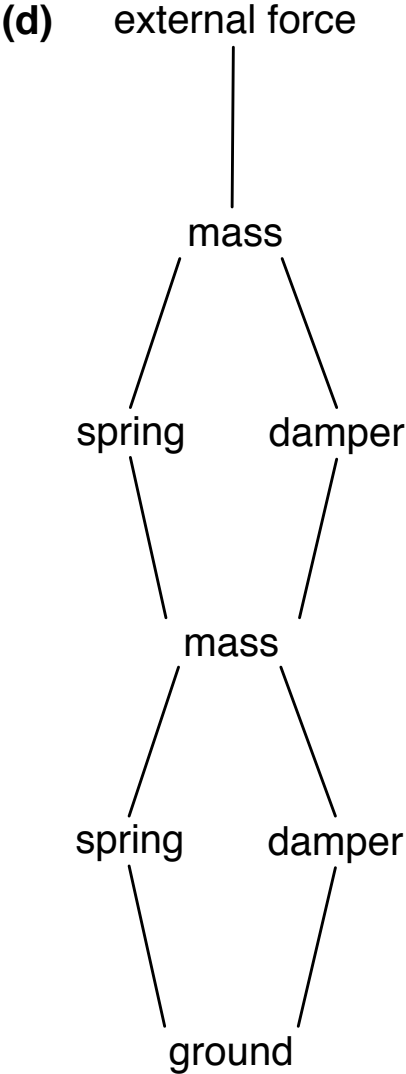
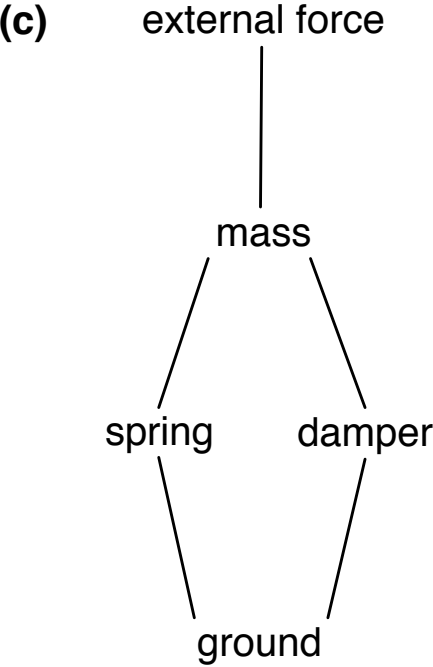
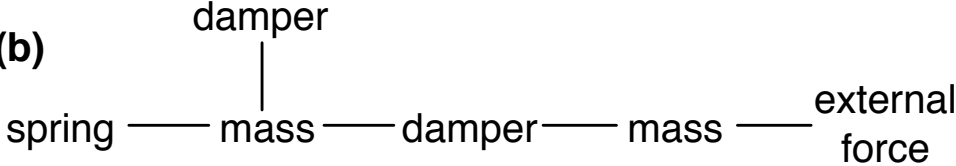
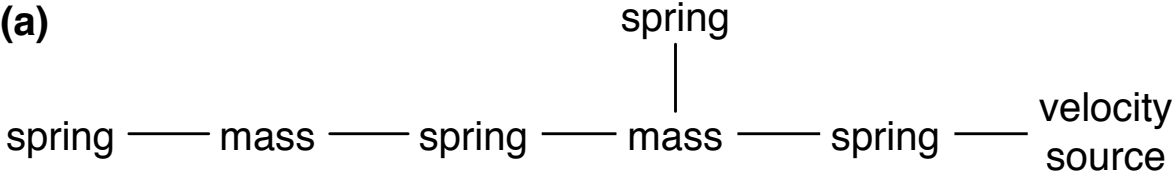
or

$$e_L = L\frac{di_L}{dt}$$

and

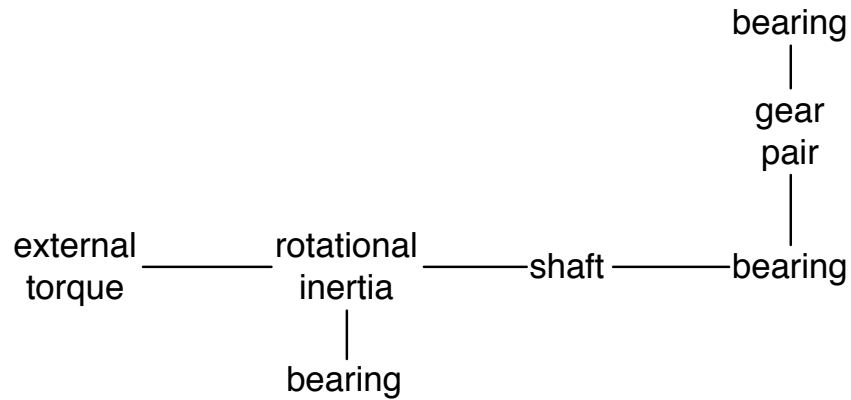
$$e_R = i_LR.$$

# P1-4

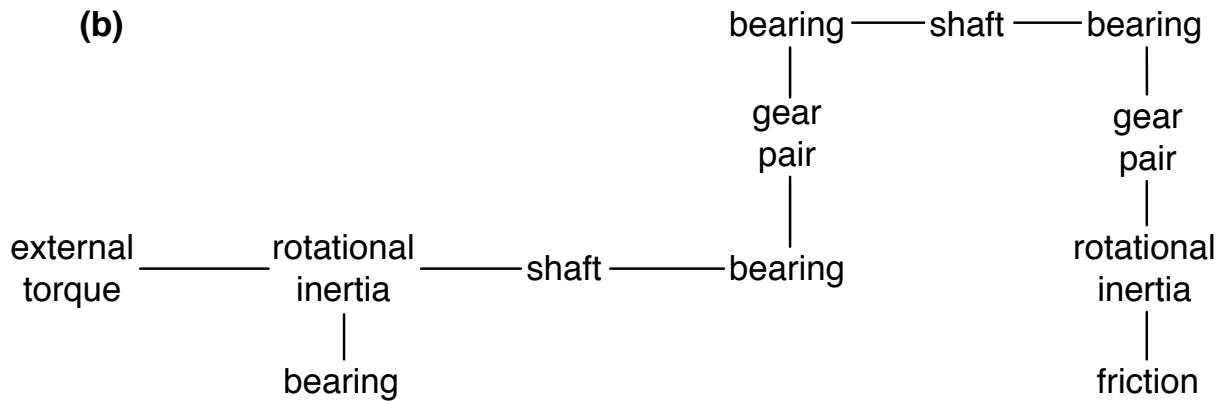


# P1-5

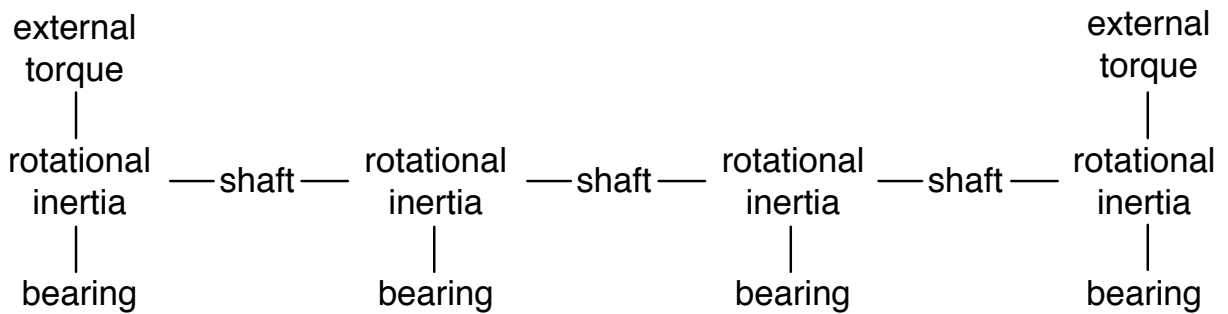
(a)



(b)



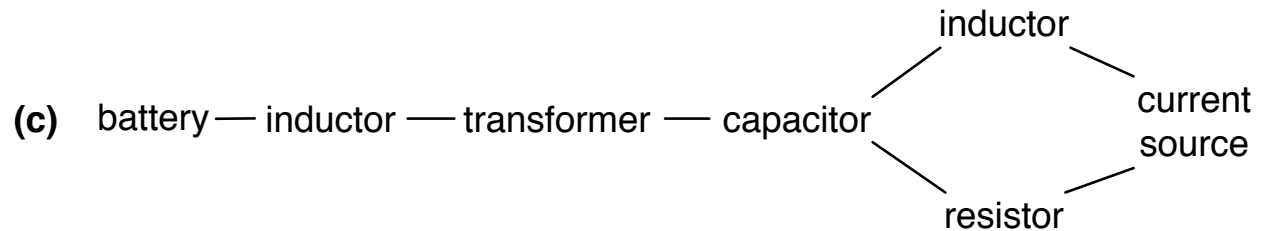
(c)



## P1-6

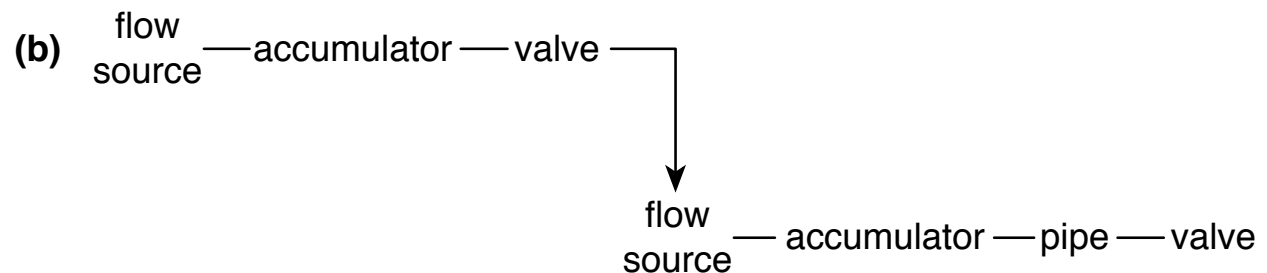
(a) battery — resistor — capacitor — inductor — resistor

(b) voltage source — inductor — transformer — resistor — capacitor



## P1-7

(a) flow source — accumulator — valve — accumulator — pipe — valve



(c) pressure source — valve — accumulator — pipe — valve — accumulator — valve

## P1-8

voltage source — inductor — resistor — ideal motor — rotational inertia — gear pair — bearing

# Chapter 2

## P2-1

| Problem | Element         | Parameter  | Element Type  | Energy    |
|---------|-----------------|------------|---------------|-----------|
| (a)     | 4 Springs       | $k$        | C-elements    | Potential |
|         | 2 Masses        | $m$        | I-elements    | Kinetic   |
|         | Velocity Source | $v(t)$     | Flow source   | Supplies  |
| (b)     | 1 Spring        | $k$        | C-element     | Potential |
|         | 2 Dampers       | $b_1, b_2$ | R-elements    | Dissipate |
|         | 2 Masses        | $m$        | I-elements    | Kinetic   |
|         | External Force  | $F(t)$     | Effort source | Supplies  |
| (c)     | 1 Spring        | $k$        | C-element     | Potential |
|         | 1 Damper        | $b$        | R-element     | Dissipate |
|         | 1 Mass          | $m$        | I-element     | Kinetic   |
|         | External Force  | $F(t)$     | Effort source | Supplies  |
| (d)     | 2 Springs       | $k_1, k_2$ | C-elements    | Potential |
|         | 2 Masses        | $m_1, m_2$ | I-elements    | Kinetic   |
|         | 2 Dampers       | $b_1, b_2$ | R-elements    | Dissipate |
|         | External Force  | $F(t)$     | Effort source | Supplies  |

## P2-2

| Problem | Element                 | Parameter  | Element Type  | Energy    |
|---------|-------------------------|--|---------------|-----------|
| (a)     | External Moment         | $\tau_m$   | Effort source | Supplies  |
|         | Bearings                | $\beta_1, \beta_2, \beta_3$                            | R-elements    | Dissipate |
|         | Shaft                   | $\kappa$   | C-element     | Potential |
|         | Rotational Inertia      | J  | I-element     | Kinetic   |
|         | Gear Pair               | $N_1/N_2$  | Transformer   | Converts  |
| (b)     | External Moment         | $\tau_m$   | Effort source | Supplies  |
|         | 4 Bearings and Friction | $\beta, \beta_{fric}$                                  | R-elements    | Dissipate |
|         | 2 Shafts                | $\kappa$   | C-element     | Potential |
|         | 2 Rotational Inertias   | J  | I-element     | Kinetic   |
|         | 2 Gear Pairs            | $N_1/N_2, N_3/N_4$                                     | Transformer   | Converts  |
| (c)     | 2 External Moments      | $\tau_1, \tau_2$                                       | Effort source | Supplies  |
|         | 3 Shafts                | $\kappa_1, \kappa_2, \kappa_3$                         | C-elements    | Potential |
|         | 6 Bearings              | $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ | R-elements    | Dissipate |
|         | 4 Rotational Inertias   | $J_1, J_2, J_3, J_4$                                   | I-elements    | Kinetic   |