

Introduction to Biomedical Engineering

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Second Edition

Errata for Second Printing

Page 133, near the bottom of the page:

"In general, a set of forces may be combined into an equivalent force denoted **by** the resultant, **R**, where..."

Page 145

Example Problem 4.5

A 160-lb person is holding a 10-lb weight in his palm with the elbow fixed at 90° flexion (Fig. 4.8, top). (a) What force must the biceps generate to hold the forearm in static equilibrium? (b) What force(s) does the forearm exert on the humerus?

Solution

Figure 4.8 (bottom) shows the free-body diagram of this system. Due to the increased number of unknowns, compared to the previous example, both Eqs. 4.35 and 4.36 will be used. **From the anthropometric relationships in Table 4.1, the segment weight (forearm and hand) is approximated as 2.2% of total body weight with the segment center of mass located 68.2% of the segment length away from the elbow axis. Note that the segment length for the “forearm and hand” segment in Table 4.1 is defined as the distance between the elbow axis and the ulnar styloid.**

Summing moments about the **point of application of the biceps force** at point O, the equilibrium equation $\Sigma \mathbf{M}_O = \mathbf{0}$ can be written as

$$\begin{aligned} \mathbf{r}_{OE} \times \mathbf{F}_A + \mathbf{r}_{OB} \times (-10 \text{ lb})\mathbf{j} + \mathbf{r}_{OP} \times (-3.5 \text{ lb})\mathbf{j} &= \mathbf{0} \\ (-2 \text{ in})\mathbf{i} \times (-F_A)\mathbf{j} + (12 \text{ in})\mathbf{i} \times (-10 \text{ lb})\mathbf{j} + (5.2 \text{ in})\mathbf{i} \times (-3.5 \text{ lb})\mathbf{j} &= \mathbf{0} \\ (2 \text{ in})F_A\mathbf{k} - (120 \text{ lb in})\mathbf{k} - (18.2 \text{ lb in})\mathbf{k} &= \mathbf{0} \end{aligned}$$

Solving this last expression for the one unknown, F_A , the vertical force at the elbow:

$$F_A = 69.1 \text{ lb}$$

To find the unknown horizontal force at the elbow, F_C , and the unknown force the biceps must generate, F_B , the other equation of equilibrium $\Sigma \mathbf{F} = \mathbf{0}$ is used:

$$F_C\mathbf{i} - F_A\mathbf{j} + (-F_B \cos 75^\circ \mathbf{i} + F_B \sin 75^\circ \mathbf{j}) - 10 \text{ lb } \mathbf{j} - 3.5 \text{ lb } \mathbf{j} = \mathbf{0}$$

Summing the **i** and **j** components gives

$$\begin{aligned} F_C - F_B \cos (75^\circ) &= 0 \\ -F_A + F_B \sin (75^\circ) - 10 \text{ lb} - 3.5 \text{ lb} &= 0 \end{aligned}$$

Solving these last two equations simultaneously and using $F_A = 69.1 \text{ lb}$ gives the force of the biceps muscle, F_B , and the horizontal elbow force, F_C :

$$\begin{aligned} F_B &= 85.5 \text{ lb} \\ F_C &= 22.1 \text{ lb} \end{aligned}$$

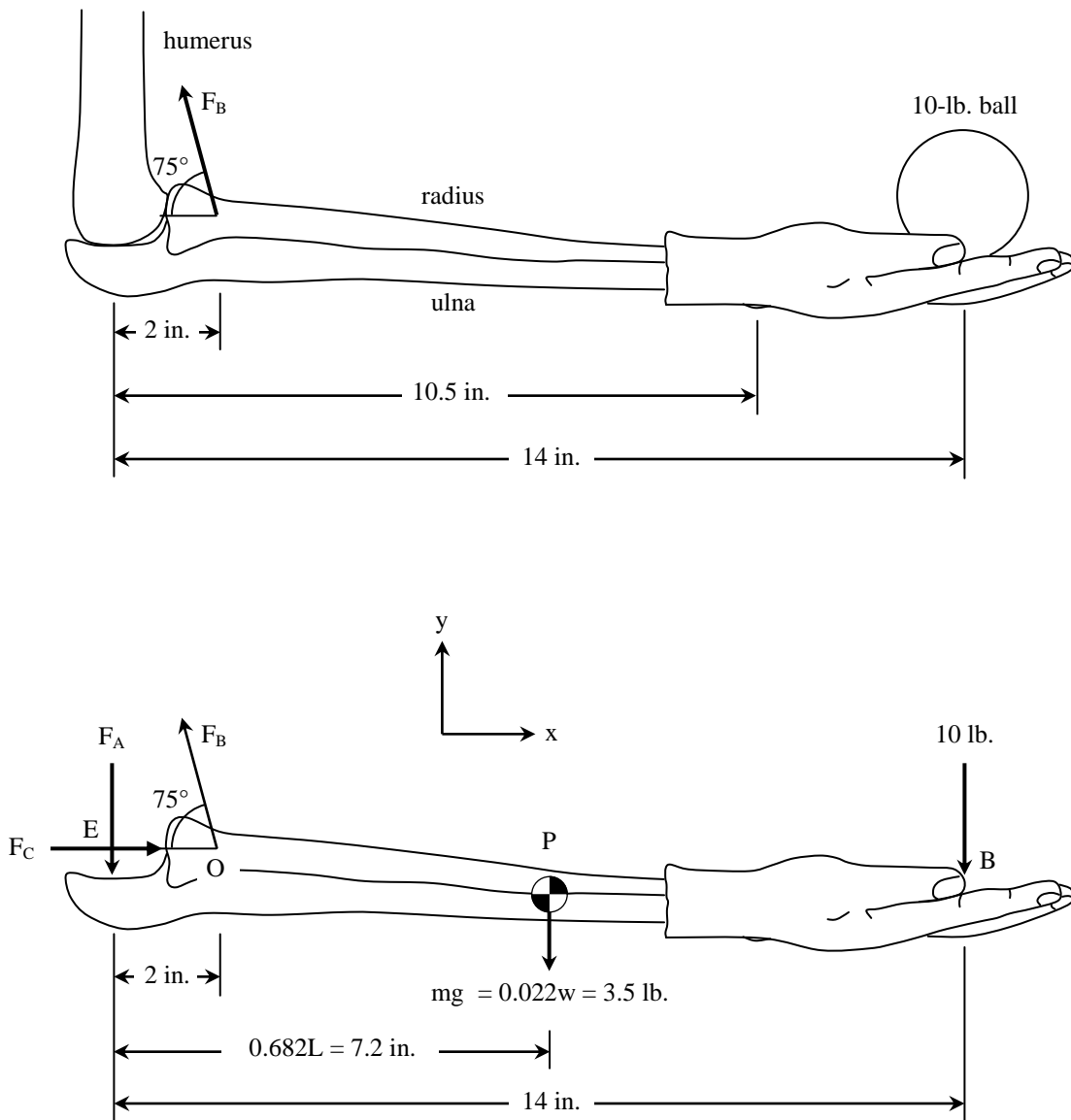


Figure 4.8 (top) The forearm held statically fixed in 90° flexion while holding a 10-lb weight in the hand. (bottom) Free-body diagram of the forearm system (adapted from Davis, 1986, Figs. 6.16 and 6.17, pp. 208–9).

Pages 247 and 248, the complete reference for Figures 5.12 and 5.13 is Szeto, A.Y.J. and R.N. White, "Evaluation of a Curb-Climbing Aid for Manual Wheelchairs: Considerations of Stability, Effort, and Safety," *Journal of Rehabilitation Research & Development*, BPR 10-38, vol. 20(1), pp. 45-56, July 1983

Page 371

$$\text{Eq. 7.19c: } D_t \frac{1}{r^2} \frac{d}{dr} \left(r^2 \frac{dC}{dr} \right) = Q_i$$

$$\text{Equation 7.20: } \bar{C} = 1 - \frac{\phi^2}{2} (1 - \bar{x}^2)$$

With Thiele moduli:

$$\phi_{slab}^2 = \frac{QL^2}{C_0D} \quad \phi_{cylinder}^2 = \frac{QR_c^2}{2C_0D} \quad \phi_{sphere}^2 = \frac{QR_s^2}{3C_0D}$$

Page 406, Figure 8.1. “1895 Roeritgen” should be “1895 Roentgen”

Page 413, the polarity for v_4 is wrong, and should be

$$\text{CP1: } -v_3 + v_1 + v_4 = 0$$

$$\text{CP2: } -v_4 + v_2 + v_5 = 0$$

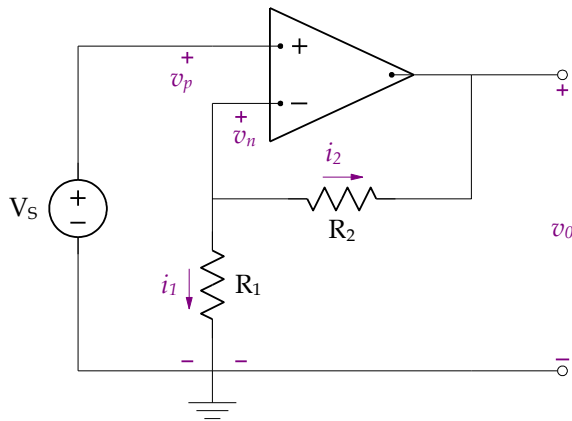
$$\text{CP3: } -v_3 + v_1 + v_2 + v_5 = 0$$

Figure 8.9, the current in B is incorrectly labeled $p=vi$, it should be just i .

Page 422, The P's below the circuit at the top of the page should be \parallel .

Page 446, third line after title, 8.10 has circuit incorrectly spelled as “cirucuit”.

Page 460, Figure for Example 8.19 should be



Page 482, This mistake was not in the first printing, but introduced in the second printing trying to make the notation more logical.

Since there are two cutoff frequencies, two equations evolve,

$$\omega_{c_H} = \frac{1}{R_{a_H} C_H} = 100 \frac{\text{rad}}{\text{s}}$$

and

$$\omega_{c_L} = \frac{1}{R_{b_L} C_L} = 500 \frac{\text{rad}}{\text{s}}$$

At the either cutoff frequency, the magnitude is $\frac{5}{\sqrt{2}}$, such that at $\omega_{c_H} = 100 \frac{\text{rad}}{\text{s}}$

$$\begin{aligned} \frac{5}{\sqrt{2}} &= \frac{R_{b_H}}{R_{a_H}} \frac{\omega_{c_H}}{\sqrt{\omega_{c_H}^2 + \left(\frac{1}{R_{a_H} C_H}\right)^2}} \frac{\frac{1}{R_{a_L} C_L}}{\sqrt{\omega_{c_H}^2 + \left(\frac{1}{R_{b_L} C_L}\right)^2}} \\ &= \frac{R_{b_H}}{R_{a_H}} \frac{100}{\sqrt{100^2 + 100^2}} \frac{\frac{1}{R_{a_L} C_L}}{\sqrt{500^2 + 100^2}} \end{aligned}$$

Page 483,

The other cutoff frequency gives the same result as the previous equation. There are now three equations

($\frac{1}{R_{a_H} C_H} = 100$, $\frac{1}{R_{b_L} C_L} = 500$ and $500\sqrt{26} = \frac{R_{b_H}}{R_{a_H} R_{a_L} C_L}$), and six unknowns. For convenience, set

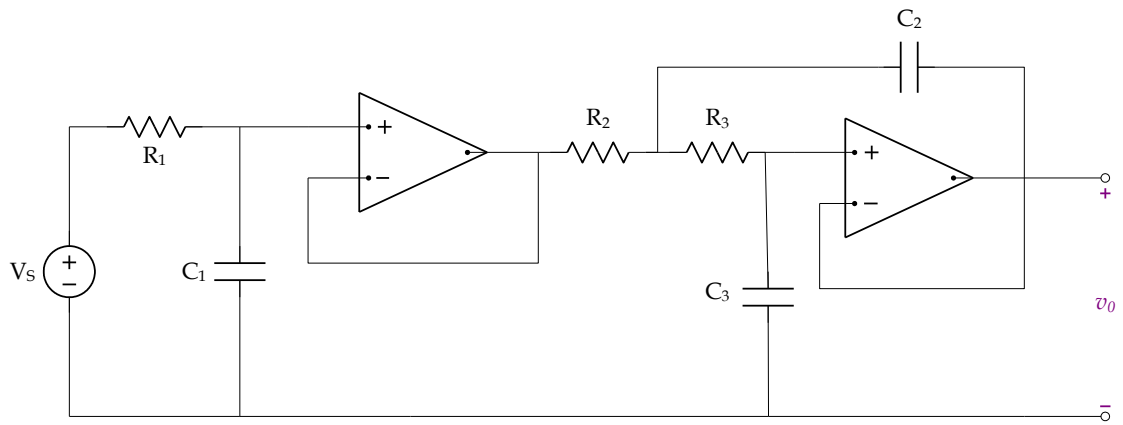
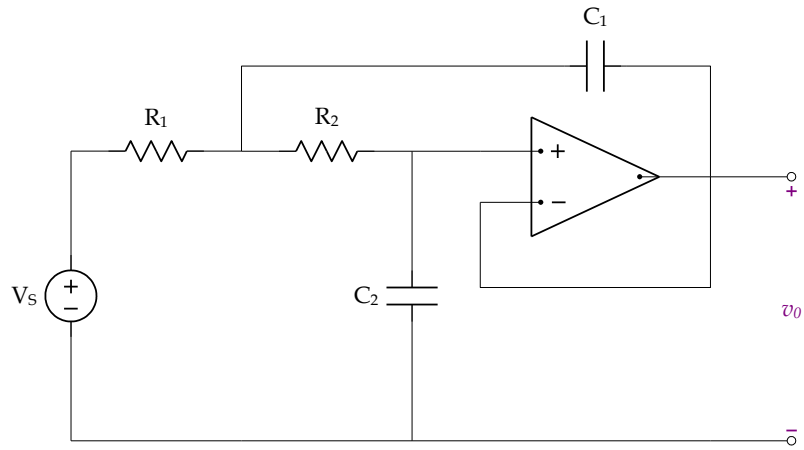
$R_{b_L} = 100 \text{ k}\Omega$ and $R_{a_H} = 100 \text{ k}\Omega$, which gives $C_L = \frac{1}{500 R_{b_L}} = 20 \text{ nF}$ and $C_H = \frac{1}{100 R_{a_H}} = 0.1 \mu\text{F}$.

Now from $500\sqrt{26} = \frac{R_{b_H}}{R_{a_H}} \frac{1}{R_{a_L} C_L}$,

$$\frac{R_{b_H}}{R_{a_L}} = 500\sqrt{26} C_L R_{a_H} = 5.099$$

Once again, one can specify one of the resistors, say $R_{a_L} = 10 \text{ k}\Omega$, giving $R_{b_H} = 50.099 \text{ k}\Omega$.

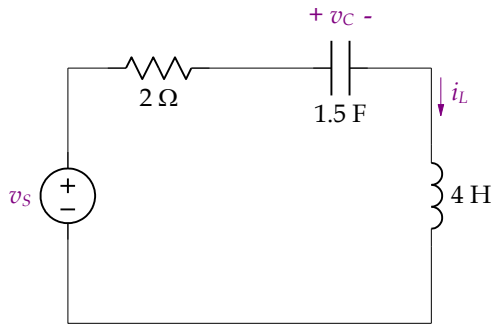
Page 484. Figure 8.38, circuits are wrong. It should be



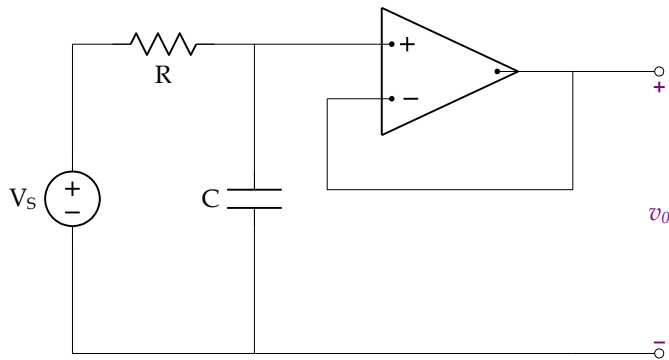
Page 496,

Ex. 30, replace (a) $v_s = 5u(t)$ V; (b) $v_s = 5u(t) + 3$ V

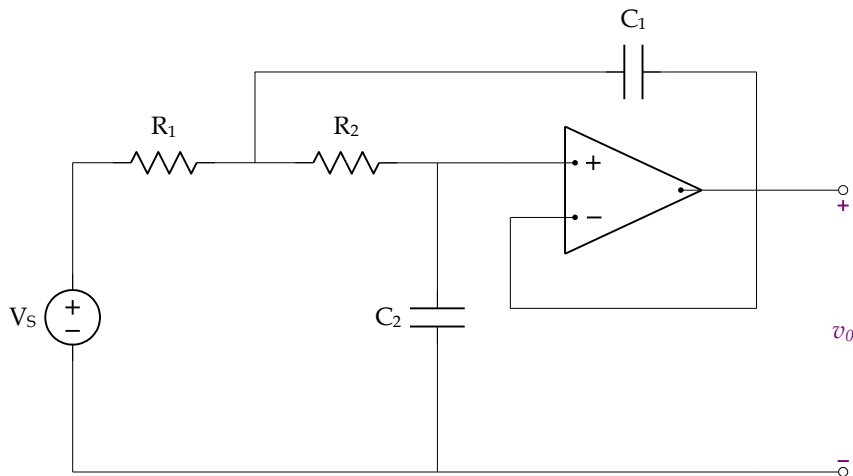
Also, change the supply voltage to v_c to v_s .



Page 503, Exercise 53, Figure is wrong (op am input terminals are reversed), should be

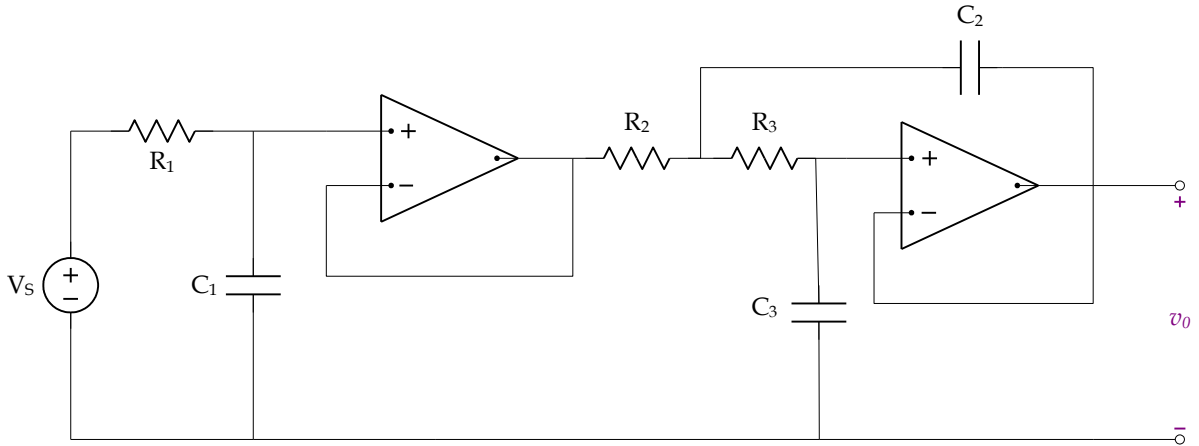


Exercise 54, Figure is wrong (op am input terminals are reversed), should be



Page 504

Exercise 55, Figure is wrong (op am input terminals are reversed), should be

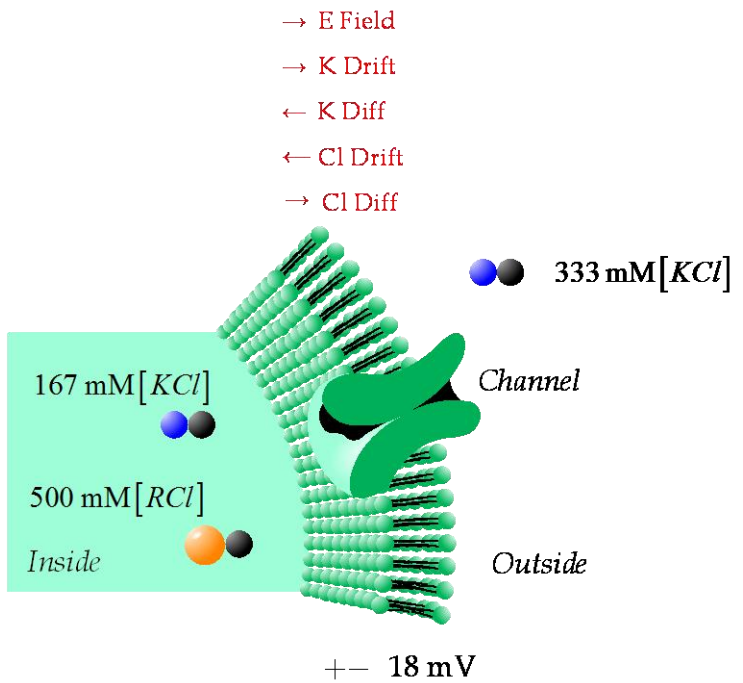


Page 550: Sec: 10.1 Introduction - third line of the first paragraph:

"...mechanical activity that occurs during these biological events often produces signals..."

Page 647

Drawing on bottom of page, Cl drift and diffusion direction are backwards.



Page 658

Eq. 11.36 should not have a negative sign

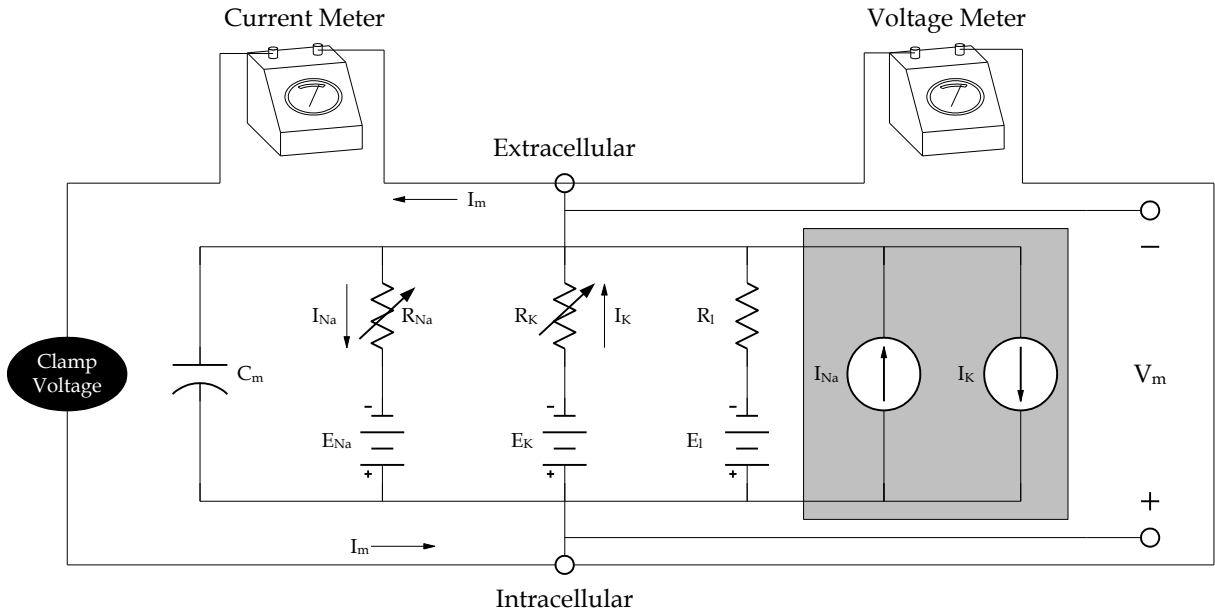
$$V_{Th} = \frac{R_{Na} R_{Cl} E_K + R_K R_{Cl} E_{Na} + R_K R_{Na} E_{Cl}}{R_{Na} R_{Cl} + R_K R_{Cl} + R_K R_{Na}}$$

$$I_i = \frac{V_m - V_{Th}}{R_{Th}}$$

Page 661 left and right should be replaced by top and bottom as shown below.

Note that in the figure on the **top**, V_m reaches steady state before the current pulse returns to zero, and in the figure on the **bottom**, V_m falls short of the steady state value reached on the **top**.

Page 666. Replace Figure 11.21 with the following one.



The Na^+ and K^+ channel resistance or conductance is easily determined applying Ohm's law to the circuit in Figure 11.20 and the current waveforms in Figure 11.21

$$I_K = \frac{V_m - E_K}{R_K} = G_K (V_m - E_K) \tag{11.39}$$

$$I_{Na} = \frac{E_{Na} - V_m}{R_{Na}} = G_{Na} (E_{Na} - V_m) \tag{11.40}$$

Figure 11.26. Diagram illustrating the change in Na^+ and K^+ conductance with clamp voltage ranging from -50 mV (below threshold) to $+20 \text{ mV}$. Note that the time scales are different in the two **conductance** plots.

Figure 11.29. Main block diagram for simulating an action potential using SIMULINK. The stimulus current is a pulse created by subtracting two step functions as described in Figure 11.30. The Na^+ and K^+ conductance function blocks are described in Figures 11.31 and 11.32.

Figure 11.25 shows the main block diagram. Figures 11.29-11.31 are subsystems that were created for ease in analysis.

Page 679

Figure 11.32. SIMULINK program for the alpha and beta terms in Equations 11.43, 11.45 and 11.46.

Page 680. One R_a is missing in the diagram

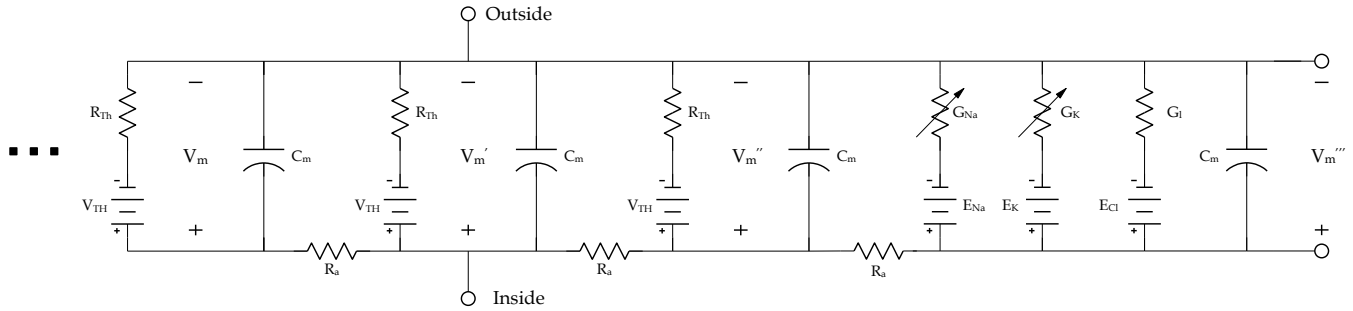
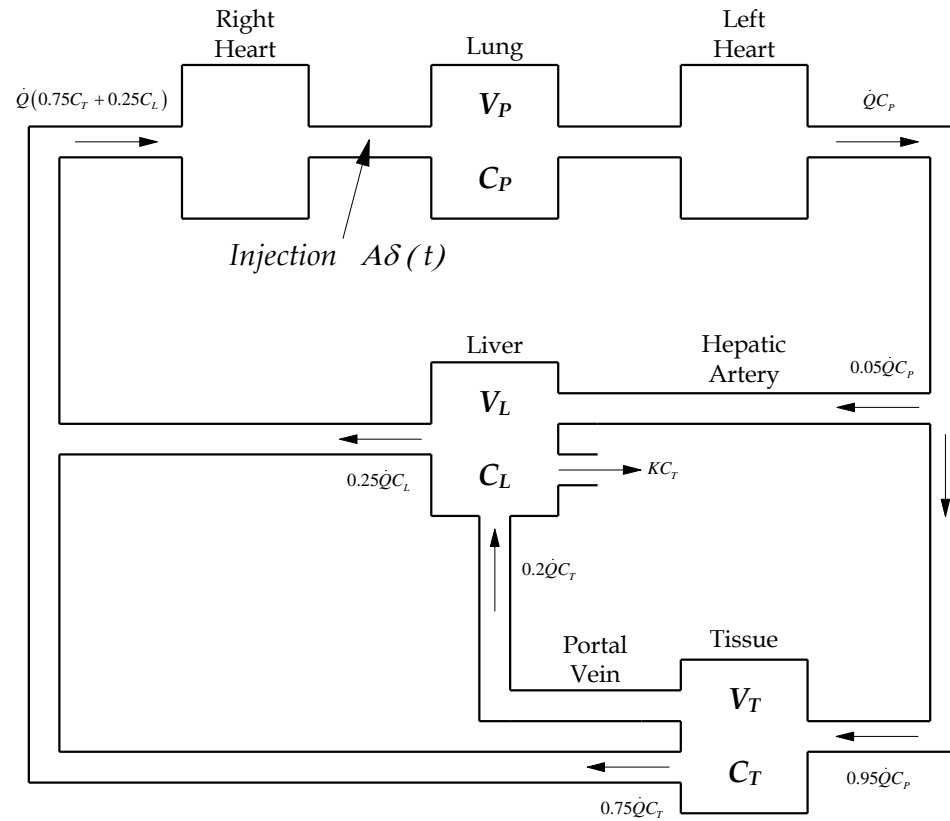


Figure 11.33. A segment of the axon with active and passive compartments.

To model the neuron in Figure 11.33, Kirchoff's current law is applied for each compartment (i.e., each line in Eq. 11.49 is for a compartment), giving

Page 719, Figure has been updated



Page 722

Above the Figure, it should be $t_d < 4\tau$ and $t_d > 4\tau$

Page 728, Eq. 12.23

$$J\ddot{\theta} + B\dot{\theta} + K\theta = \tau(t)$$

Page 765, Eq. 12.60 (the θ should be x)

$$K_{SE}K_{12} \ddot{F}_{ag} - \dot{F}_{ant} + K_{SE}B_{34} + B_2K_{12} \dot{F}_{ag} - \dot{F}_{ant} + B_2B_{34} \ddot{F}_{ag} - \ddot{F}_{ant} = C_4 \overset{\dots}{x} + C_3 \overset{\dots}{x} + C_2 \overset{\dots}{x} + C_1 \overset{\cdot}{x} + C_0 x$$

Page 774, Eq. 12.69 (cosine term in the integral should not have a t variable $\cos \omega_x \lambda \cancel{t} + \theta$)

$$V_i j\omega = F A \cos \omega_x t + \theta = A \int e^{-j\omega\lambda} \cos \omega_x \lambda + \theta d\lambda = A \int e^{-j\omega\left(\frac{\theta}{\omega_x} + \tau\right)} \cos \omega_x \tau d\tau$$

Page 784, middle of the page

$$\tau = 0.17 \text{ s}$$

Page 785

$$v(t) = 2.28 \left(1 - e^{-\frac{t}{0.17}} \right) u(t)$$

Page 787

First find ζ by using the Equation 12.83.

Page 788,

Ex. 3. transfer rate is $27 \times 10^3 \text{ s}^{-1}$

Page 789,

Ex. 5. Change q_1 to c_1 .

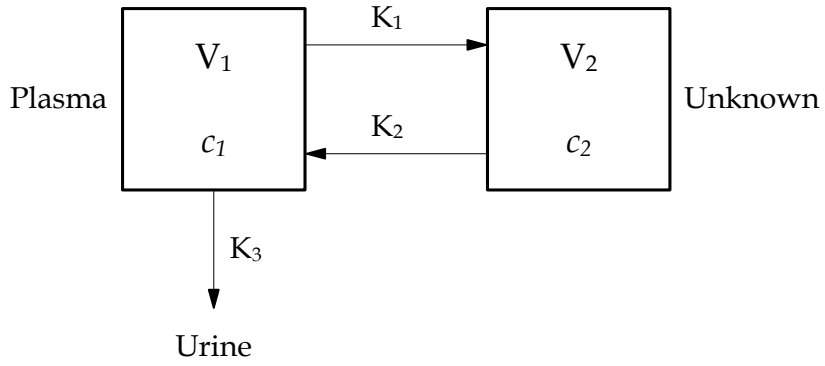
c_1 = concentration of substance in plasma (mg/100 mL)

A_1 = 143 mg/100 mL

A_2 = 57 mg/100 mL

The amount of substance injected equals 10 g.

Figure should be



Part (b) of Exercise 7, change to

(b) Determine the transfer rates K_{12} , K_{13} , and K_{21} .

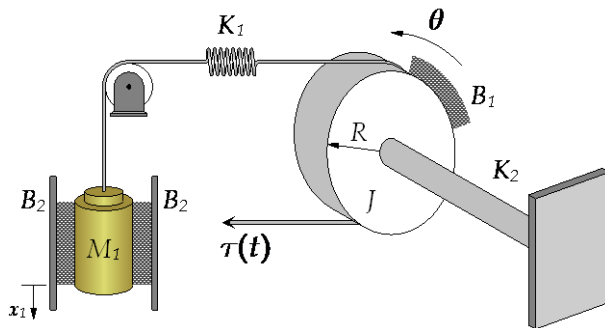
Ex. 9. Change q to c .

$$c_1 = 143e^{-1.6t} \frac{\text{mg}}{100\text{ml}}$$

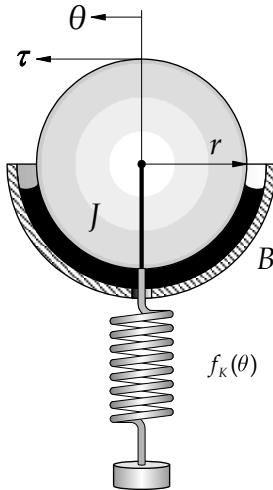
Page 791

Problem 10, "Exercise 12.1" should be "Example Problem 12.1".

Page 792, Figure for Problem 21 (q should be θ)



Page 795 Error in the nonlinear spring in Figure



Page 797

Suppose a second-order underdamped system response to a step is given by Equation 12.81 and has $C = 10$, $T_p = 0.050$ and $x(T_p) = 10.1$. Find ζ and ω_n .

Pages 842-844:

The line of code calling the ODE solver should read:

```
[t,Y]=ode23(@s_model,[0 100],[0 0 0],options);
```

or

```
[t,Y]=ode23('s_model',[0 100],[0 0 0],options);
```


Page 846:

Equation 14.17 should be:
$$\frac{dR_p}{dt} = \frac{V_1 S (R - R_p)}{k_1 + (R - R_p)} - \frac{V_2 R_p}{k_1 + R_p}$$

Page 1079, 1st paragraph, parameters for the step function are wrong.

The input is a pulse with magnitude 120 and duration of 10. To create a pulse, we use two step inputs from the



Library “Sources”. The step input block looks like ; to enter the magnitude and duration, double-click on the block to open the “Block Parameters Step” and enter for the first block 0 for “Step Time”, 0 for the “Initial value” and 120 for the “Final value”. The second step function uses the values 10 for the “Step Time”, 0 for the “Initial value” and -120 for the “Final value”. Another summer with line segments from the output of the step to the input of the summer is used to connect the two inputs. The output of the input summer is connected to the “+” input of the first summer.