1. Consider a system with processes $P_1$, $P_2$, and $P_3$, one instance of resource $R_1$, and two instances of resource $R_2$. For the following two cases, draw the resource allocation graph, state if a deadlock is involved, and explain why or why not. Assume that processes will hold resources until they terminate, and that they must receive all requested resources in order to complete their processing:

- **Case 1**, in which:
  - $P_1$ is waiting for instances of $R_1$ and $R_2$.
  - $P_2$ holds instances of $R_1$ and $R_2$.
  - $P_3$ is waiting for an instance of $R_1$ and holds an instance of $R_2$.

- **Case 2**, in which:
  - $P_1$ holds an instance of $R_1$ and is waiting for an instance of $R_2$.
  - $P_2$ is waiting for an instance of $R_1$ and holds an instance of $R_2$.
  - $P_3$ is waiting for an instance of $R_1$ and holds an instance of $R_2$.

2. Problem 7.11 on p. 342 of your text (it was Problem 7.2 on p. 299 in the previous edition).

3. The following problem uses the resource-allocation-graph algorithm for deadlock avoidance from Section 7.5.2 of the course text. Note that it uses a variant of the resource allocation graph that includes *claim edges*. Consider a system with a single instance each of four resources $R_1$, $R_2$, $R_3$, and $R_4$. Three processes are running on the system:

- $P_1$, which may request resources $R_1$, $R_3$, and $R_4$;
- $P_2$, which may request resources $R_2$, $R_3$, and $R_4$; and
- $P_3$, which may request resources $R_1$, $R_2$, and $R_4$.

Consider the following sequence of events:

- $P_2$ requests $R_3$
- $P_1$ requests $R_1$
- $P_3$ requests $R_4$
- $P_2$ requests $R_2$
- $P_1$ **releases** $R_1$
- $P_3$ requests $R_2$
Indicate which of the requests are allowed by the algorithm, and which are denied. Draw the resource allocation graph (including claim edges) after each event; if an event involves a request, your drawing should show the graph after the event is either allowed or denied.

4. Problem 7.17 on p. 343 of the course text (it was Problem 7.12 on p. 301 in the previous edition).