# Solution

1. Discounting is used to make one-time investment costs and salvage values commensurate with per-period operating costs.
2. For example, frequent short machine failures are less disruptive than long, infrequent failures. See page 251 of Factory Physics for other examples.
3. Difference due to the relative cost differences of Time vs. Inventory buffers, where Make-to-Stock has High and Low costs, respectively, and Make-to-Order has Low and High costs, respectively, for each type of buffer.

| Capacity | Time | Inventory | Production System |
|---|---|---|---|
| Low | Low | Low | Home production (a.k.a. putting-out system) |
| Low | High | Low | Dedicated make-to-stock (mass production) |
| Low | Low | High | Dedicated make-to-order, Home cooking |
| Low | High | High | Restaurant |
| High | Low | Low | Craft production, Process plant (continuous mfg) |
| High | High | Low | Shared make-to-stock (discrete part mfg) |
| High | Low | High | Shared make-to-order (job shop), Doctor's office |
| High | High | High | Trauma unit at hospital, Additive manufacturing |

4.

$$F = 15{,}000 \text{ q/yr}, \quad H = 365.25 \times 16 = 5{,}844 \text{ hr/yr}, \quad c = \frac{OC}{F} = \frac{2{,}500{,}000}{F} = \$166.67/\text{q}, \quad p = \$325/\text{q}$$

$$K = \$500{,}000, \quad u = 0.35, \quad r_d = \frac{F}{H} = 2.5667 \text{ q/hr}, \quad r_e = \frac{r_d}{u} = 7.3335 \text{ q/hr}, \quad k = \frac{(K/H)}{r_e} = \$11.67/\text{q}$$

$$F_{\text{new}} = 20{,}000 \text{ q/yr}, \quad r_{d,\text{new}} = \frac{F_{\text{new}}}{H} = 3.4223 \text{ q/hr}, \quad t_g = 0.5 \text{ hr}, \quad x_g = 0.25, \quad g = \frac{p x_g}{(p-c) t_g} = 1.0263$$

$$r^*_{e,\text{new}} = r_{d,\text{new}} + \sqrt{\frac{(p-c)\, g\, r_{d,\text{new}}}{k}} = 10.3265 \text{ q/hr}$$

5.

| | | Base | | | |
|---|---|---|---|---|---|
| W/S | | 1 | 2 | 3 | Total |
| Arrival Rate | ($r_a$, q/hr) | 47.0588 | 40 | 32 | |
| Natural Process Time | ($t_0$, hr/q) | 0.33333 | 0.5 | 0.25 | |
| Availability | ($A$) | 1 | 1 | 1 | |
| Effective Process Time | ($t_e$, hr/q) | 0.33333 | 0.5 | 0.25 | |
| Yield | ($y$) | 0.85 | 0.8 | 0.75 | |
| Yield Occurance Factor | ($\gamma$) | 0.5 | 0 | 1 | |
| Throughput ($r_d + \gamma(r_a - r_d)$) | ($r$, q/hr) | 43.5294 | 32 | 32 | |
| Number of M/C | ($m$) | 15 | 17 | 9 | |
| Utilization | ($u$) | 0.96732 | 0.94118 | 0.88889 | |
| Departure Rate ($r_a$*$y$) | ($r_d$, q/hr) | 40 | 32 | 24 | |
| M/C Cost | ($000) | 50 | 100 | 75 | |
| W/S Cost | ($000) | 750 | 1700 | 675 | 3,125 |

6.

| | | |
|---|---|---|
| Interarrival Time | ($t_a$, hr/q) | 0.166667 |
| Arrival Rate | ($r_a$, q/hr) | 6 |
| Interarrival STD | | 0.083333 |
| Arrival SCV | ($c^2_a$) | 0.25 |
| Natural Process Time | ($t_0$, hr/q) | 0.333333 |
| Natural Process SCV | ($c^2_0$) | 0 |
| MTTF | (hr) | 6 |
| MTTR | (hr) | 4 |
| Repair Time SCV | ($c^2_r$) | 0.625 |
| Availability | ($A$) | 0.6 |
| Effective Process Time | ($t_e$, hr/q) | 0.555556 |
| Eff Process Time SCV | ($c^2_e$) | 4.68 |
| Number of M/C | ($m$) | 4 |
| Utilization | ($u$) | 0.833333 |
| Cycle Time in Queue | ($CT_q$, hr) | 1.384917 |
| Cycle Time at W/S | ($CT$, hr) | 1.940473 |
| WIP in Queue ($r_a$*$CT_q$) | ($q$) | 8.309504 |
| WIP at W/S | ($q$) | 11.64284 |