(2) **Question 1.** Add more {energy, power, current, voltage} to get more bandwidth.

(6) **Question 2.** This system has a read-modify-write critical section in main.
(4) **Part a)** H) Remove the line `PTP ^= 0x40;`
(2) **Part b)** E) Minimally intrusive

(4) **Question 3.** A,B,CCR,X,Y,PC is 9 bytes.
(4) **Question 4.** A data flow problem where data is produced twice as fast as it is consumed.
   D) The system does not work, but could be corrected by increasing baud rate
(4) **Question 5.** The capacitor behaves like \( I = C \frac{dV}{dt} \)
   F) The \( \frac{dV}{dt} \) at 100ns will be about \( 5V/(RC) \)
(4) **Question 6.** Binary fixed-point is faster/easier for calculations
   E) Signed 16-bit binary fixed-point with 2^-8 resolution
(6) **Question 7.** output of one digital circuit is connected to the input of another digital circuit.
(2) **Part a)** Current sinks into the output when low
   A) Right to left
(2) **Part b)** Current sources out of an output when high
   B) Left to right
(2) **Part c)** Capacitance slows down digital signals. It takes longer to send each bit
   B) The bandwidth decreases

(4) **Question 8.** The following waveform was measured on the PS1 output
(2) **Part a)** Bit time is 2ms, baud rate is 500 bits/sec.
(2) **Part b)** start,1,0,0,1,1,0,1,stop. $B9$

(8) **Question 9.** There are three decimal fixed point numbers: \( X = I \times 10^{-1} \), \( Y = J \times 10^{-2} \), \( Z = K \times 10^{-2} \).
(4) **Part a)** \( Z = X \times Y \). Substitute \( K \times 10^{-2} = I \times 10^{-1} \times J \times 10^{-2} \).
   D) \( K = \frac{(I \times J)}{10} \)
(4) **Part b)** \( Z = X + Y \) Substitute \( K \times 10^{-2} = I \times 10^{-1} + J \times 10^{-2} \).
   B) \( K = (10 \times I) + J \)

(4) **Question 10.** State the DAC parameter determined by each.
   Part a) Resolution   Part b) Precision   Part c) Accuracy   Part d) Monotonic

(4) **Question 11.** Get permission from the author and retain or add references to the author. If you cannot get permission, you can search for patent protection. If the theory is not protected by IP, then you could create your own implementation based on the theory.

(4) **Question 12.** \( \delta V = \frac{\Delta V}{\Delta t} \times \delta t \), where \( \delta V \) is the voltage error, \( \Delta V/\Delta t \) is the slew rate of the input, and \( \delta t \) is the sampling jitter.

(4) **Question 13.** \( T_{\text{life}} = \frac{E}{I} \), where \( T_{\text{life}} \) is the operating life of the product in hours. \( E \) is energy stored in the battery in amp-hr, and \( I \) is the average current used by the device in amps.
(2) **Question 14.** C0G X7R and Z5U refer to ceramic capacitor types. C0G is best.

(5) **Question 15.** Solve for noise, \( 40 = 20 \log_{10}(5V/noise) \), \( 2 = \log_{10}(5V/noise) \), \( 100 = 5V/noise \), thus \( noise = 50mV \). 7 bits is enough. A 7-bit ADC has a resolution of \( 5V/128 = 40 \text{ mV} \).

(5) **Question 16.** L293 or TPIC9197B are the two possibilities from the book.

(5) **Question 17.** Two bytes are transferred every 1 ms, one byte in each direction. 2000 bytes/sec.

(10) **Question 18.** There is a negative logic push-button interfaced to PP0.

(4) **Part a)** Show the ritual used to initialize the system, including interrupt enable.

```c
void Key_Init(void) {
    Count = 0;
    DDRP &= ~0x01;  // PP0 is input
    PPSP &= ~0x01;  // falling edge active
    PIEP |= 0x01;   // arm PP0
    PIFP = 0x01;    // clear flag
    asm cli           // enable interrupts
}
```

(4) **Part b)** Show the Port P key wakeup ISR.

```c
interrupt 56 void Keyhandler(void) {
    PIFP = 0x01;    // clear flag
    Count++;        // key touch
}
```

(2) **Part c)** It takes about \( 1 \mu s \) to execute the ISR once. The exact answer is 9 cycles to suspend main and launch ISR, 3 cycles for \( PIFP=0x01 \), 7 cycles for \( Count++ \) assuming \( Count \) is 16 bits, and 8 cycles for RTI. This is a total of 27 cycles, which is about \( 1 \mu s \).

(10) **Question 19.** Design an analog LPF filter with a cutoff of 50 kHz.

2 pole Butterworth analog filter, \( R = 10 k\Omega \)

1) select the cutoff frequency, \( f_c=100 \text{ kHz} \)
2) divide the two capacitors by \( 2\pi f_c \)
   \[ C_{1A} = \frac{141.4 \mu F}{2\pi f_c} = \frac{141.4 \mu F}{2\pi 40000} = 450 \text{ pF} \]
   \[ C_{2A} = \frac{70.7 \mu F}{2\pi f_c} = 225 \text{ pF} \]
3) Choose \( C_{1B} = 200 \text{ pF} \) and \( C_{2B} = 100 \text{ pF} \)
   let \( C_{1B}, C_{2B} \) be these standard value capacitors, let \( x \) be this factor
   \[ C_{1B} = C_{1A}/x, \; x = 450/200 \]
   \[ C_{2B} = C_{2A}/x \]
4) adjust the resistors to maintain the cutoff frequency
   \[ R = 10k\Omega \times x = 22.5 \text{ k}\Omega \]

(5) **Question 20.** This is a great FIFO. I found it as part of the Keil example files for the Arm. It is easy to change. It runs a little slower than the one in the book.

(2) **Part a)** “Yes it works”

(2) **Part b)** “There are NO critical sections”

(1) **Part c)** “Yes it works”