Spoiler alert: The following content contains spoilers to worksheet 2. If you have not done so already, you are strongly recommended to try out those questions yourself first.

2. **Binary Strings**

   a. $00^* \cup (0 \cup 1)^*000$ (that is, either all 0s or ends with three 0s)

   b. $(01)^*(0 \cup \varepsilon) \cup (10)^*(1 \cup \varepsilon)$

   c. $(\Sigma 0(((\Sigma\Sigma)^*\Sigma 0) \cup \varepsilon)) \cup (\Sigma 1(((\Sigma\Sigma)^*\Sigma 1) \cup \varepsilon)) \cup (\Sigma 1(\Sigma\Sigma)^*0)$

3. **Substring**

   a. $0^*(1(1 \cup \varepsilon)0^*0)^*(11 \cup 1 \cup \varepsilon)$

   b. $(0 \cup \varepsilon)(10)^*(1 \cup \varepsilon)$

   c. $0^* \cup 1^*$

5. **Binary Comparison Operators**

   a. 0^*1110

   b. $0^*(11(0 \cup 1)(0 \cup 1) \cup 101(0 \cup 1) \cup 1(0 \cup 1)(0 \cup 1)(0 \cup 1)(0 \cup 1)(0 \cup 1)^*)$

   c. $0^*(1 \cup 10 \cup 11 \cup 100 \cup 101 \cup 110 \cup 111 \cup 1000 \cup 1001)$

   d. $0^*(11(0\cup1)(0\cup1)\cup101(0\cup1)\cup1(0\cup1)(0\cup1)(0\cup1)(0\cup1)(0\cup1)^*\cup1\cup10\cup11\cup100\cup101)$

7. **Alternative Regular Expressions**

   a. One direction: L^* can be expressed as $\{\varepsilon \cup L^+\}$.
   For reverse direction, L^+ can be expressed as LL^*

   b. One direction: $A \cup B$ can be expressed as $(A \circ A) \circ (B \circ B)$.
   For reverse direction(slightly tricky): If we have $A \circ B$, we can convert A and B to their DFAs, invert states, and convert back to regular expressions to get A^c and B^c. Now, $A \circ B = A^c U B^c$