1 **Glossary Items**.   
Define these terms in ways that distinguish them from each other.

a.) Parallel port.

b.) Serial port

2 **Parallel Ports on the Arduino**.   
In section 1.1of the [ATmega328P datasheet](http://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-7810-Automotive-Microcontrollers-ATmega328P_Datasheet.pdf), the available parallel ports on this microcontroller are   
named. What are the names of the parallel ports on the ATmega328P? (Hint: There are three.)

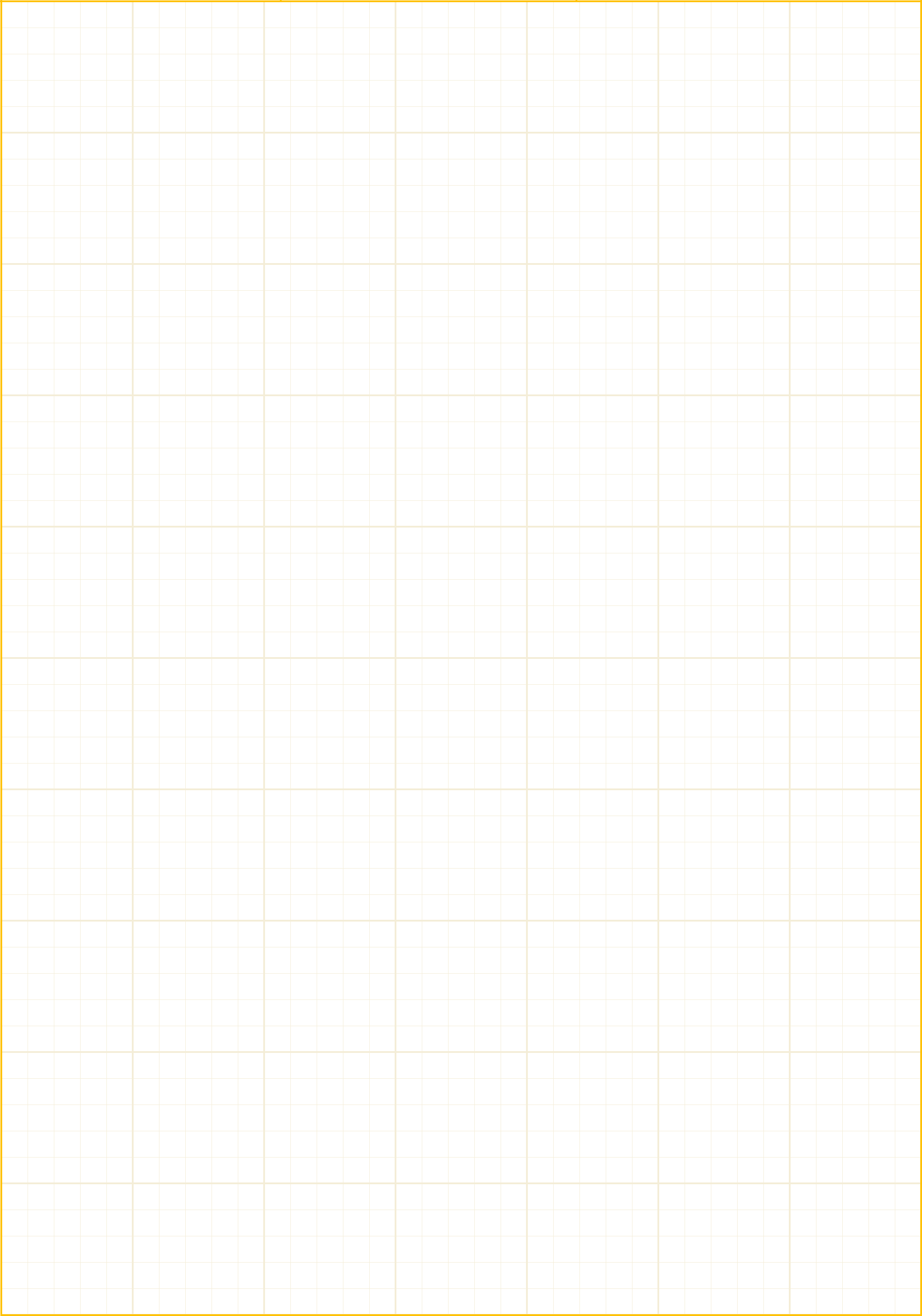
3 **Parallel Ports in the Arduino IDE.**   
Procedures provided by an IDE can cast a new perspective over the programmer’s view of the underlying hardware. Arduino IDE makes it appear as if the Arduino Uno has one 13-bit-wide parallel port. It furthermore encourages each individual bit to be configured individually such that one could alternatively think of the Arduino Uno as having 13 parallel ports, each just 1 bit wide. From the [documentation of the Arduino IDE](https://www.arduino.cc/en/Tutorial/Foundations), name the procedures available for manipulating the parallel port pins. (Hints: Within the Arduino documentation the concept of a parallel port is often described using the initialism GPIO or the phrase, *digital pins*. There are three procedures provided for manipulating these pins, two of which are used in the “[Blink](https://www.arduino.cc/en/Tutorial/Blink)” example.)

4 **Light an LED.**   
a.) What current is correct for a Light-On (brand) [LTL-4234](https://media.digikey.com/pdf/Data%20Sheets/Lite-On%20PDFs/LTL-4234.pdf) (Manf. p/n) green LED?

b.) What voltage across the LED will result if it is properly driven with the correct current?

c.) An Arduino Uno operates on a 5 V power supply.   
 An output pin, when driven low under load will typically be at about 0.4 V.  
 What resistance in series with the LED is needed to establish the correct operating current in the LED?

d.) Draw a schematic showing how to connect the LED so that it lights up when the pin is at logic-0. (LOW)

5 **Read about** [**multiplexing and charlieplexing**](https://www.divilabs.com/2013/06/led-array-multiplexing-charlieplexing.html) **LEDs.**.

Suppose a clock display is needed. Seven-segment displays will be used. Four digits are needed, two for the hour display, and two for the minute display. The seven-segment displays are available as common-cathode or common anode—they look identical but are electrically connected differently. Note that all of one digit’s display must be common cathode or all of it must be common anode. Within a digit you may not mix common cathode and common anode. (Or else it is not “common”!)

a.) Draw a schematic to show how an Arduino Uno can drive such a four-digit display. Take advantage of the human eye’s persistence of vision. (All segments and digits do not need to be simultaneously on so long as the period at which any segment flickers is less than about 15 ms.)

b.) Explain how to make your display show 12:34. Give some detail specifically on how to make the “1” in the display show up properly. Then generalize from that to show how to make the other digits display.