**CS 0447 – Fall 2017**

**Lab 7: Division**

*Released: Friday 27 October 2017, 6:00am*

***Due: Monday 6 November 2017, 23:00pm***

Each of you should submit your own solution. If you choose to work with a neighbor/partner, put your partner’s name on your submitted copy of the lab. Late submissions will not be accepted.

To help you practice for an upcoming exam, consider working each problem in pen or pencil on a hard copy of this document. Then, **enter your answers into CourseWeb.**

1. Show the steps for dividing the dividend 1011 1011b by the divisor 0000 1110b (both **unsigned**) using **restoring division** for Hardware Design 3. Restoring division is described online, with an example, at

<http://www.cs.pitt.edu/~childers/CS0447/lectures/division.pdf>.

Populate the cells of the following table. Within it, **show your work** for each addition/subtraction.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Restoring Division**  **(Hardware Design 3)** | Remainder Register (16 bits) | | | | | | | | | | | | | | | | |
| Iteration | Divisor (8 bits) | Step | Remainder (8 bits) | | | | | | | | Dividend (8 bits) | | | | | | | | |
| 0 | 0000 1110 | Initial values | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | | 0 | 1 | 1 |
| Shift left | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | | 1 | 1 | X |
| 1 | 0000 1110 | R = R–Divisor | 1  1 | 1  1 | 1  1 | 1  1 | 0  0 | 0  0 | 1  1 | 0  1 | 0 | 1 | 1 | 1 | | 0 | 1 | 1 | X |
|  | R<0, restore, set Q 0, shift left | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | | 1 | 0 | X |
| 2 | 0000 1110 | R = R–Divisor | 1  1 | 1  1 | 1  1 | 1  1 | 0  0 | 0  1 | 1  0 | 0  0 | 1 | 1 | 1 | 0 | 1 | | 1 | 0 | X |
|  | R<0, restore, set Q 0, shift left | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | | 0 | 0 | X |
| 3 | 0000 1110 | R = R–Divisor | 1  1 | 1  1 | 1  1 | 1  1 | 0  0 | 0  1 | 1  1 | 0  1 | 1 | 1 | 0 | 1 | 1 | | 0 | 0 | X |
|  | R<0, restore, set Q 0, shift left | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | | 0 | 0 | X |
| 4 | 0000 1110 | R = R–Divisor | 11 | 1  1 | 1  1 | 1  1 | 0  1 | 0  1 | 1  0 | 0  1 | 1 | 0 | 1 | 1 | 0 | | 0 | 0 | X |
|  | R<0, restore, set Q 0, shift left | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | | 0 | 0 | X |
| 5 | 0000 1110 | R = R–Divisor | 10 | 10 | 1  0 | 1  0 | 0  1 | 0  0 | 1  0 | 0  1 | 0 | 1 | 1 | 0 | 0 | | 0 | 0 | X |
|  | R>0, set Q 1, shift left | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | | 0 | 1 | X |
| 6 | 0000 1110 | R = R–Divisor | 1  0 | 1  0 | 10 | 10 | 00 | 01 | 1  0 | 0  0 | 1 | 1 | 0 | 0 | 0 | | 0 | 1 | X |
|  | R>0, set Q 1, shift left | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | | 1 | 1 | X |
| 7 | 0000 1110 | R = R–Divisor | 1  1 | 11 | 11 | 11 | 0  1 | 0  0 | 1  1 | 0  1 | 1 | 0 | 0 | 0 | 0 | | 1 | 1 | X |
|  | R<0, restore, set Q 0, shift left | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | | 1 | 0 | X |
| 8 | 0000 1110 | R = R–Divisor | 1  0 | 10 | 10 | 10 | 00 | 01 | 10 | 01 | 0 | 0 | 0 | 0 | 1 | | 1 | 0 | X |
|  | R>0, set Q 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | | 1 | 0 | 1 |
| Done |  |  | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | | 1 | 0 | 1 |

**FINAL RESULT: 1011 1011b ÷ 0000 1110b = 0000 1101 rem 0000 0101**