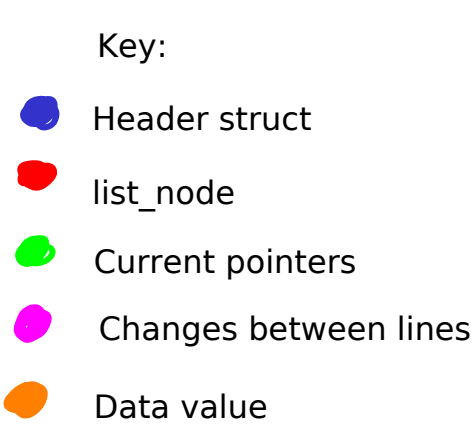

Queue and Stack Manipulation

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Suppose you have queues and stacks implemented using linked lists as shown in lecture, with integer data. Specifically, you have the following structs:

```
struct list_node {
    int data;
    struct list_node *next;
};
typedef struct list_node list;

struct queue_header {
    list *front;
    list *back;
};
typedef struct queue_header* queue;

struct stack_header {
    list *top;
    list *bottom;
};
typedef struct stack_header* stack;
```

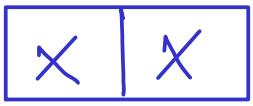
Recall from lecture that in both stacks and queues, we always keep one dummy node. In queues, `back` points to this dummy node, and in stacks, `bottom` points to this dummy node. Its fields are uninitialized, and it simply ensures that we never need to worry about `front`, `back`, `top`, or `bottom` being null.

Problem 0 (Warmup)

Recall the code for `queue_new()`:

```
queue queue_new()
//@ensures is_queue(\result);
//@ensures queue_empty(\result);
{
  1: queue Q = alloc(struct queue_header);
  2: list* p = alloc(struct list_node);
  3: Q->front = p;
  4: Q->back = p;
  5: return Q;
}
```

Draw the state of the queue after each given line of code. Use `X` for uninitialized fields.

1. 

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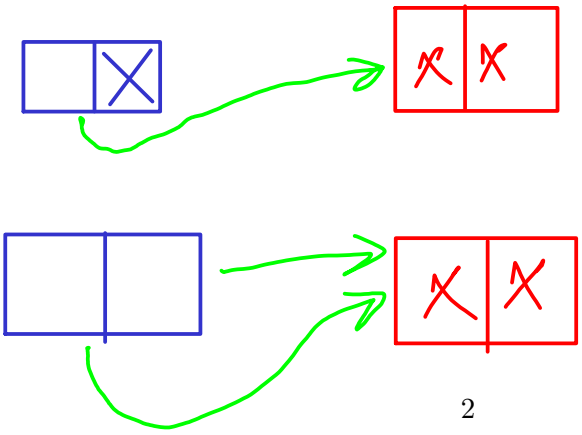
4. 

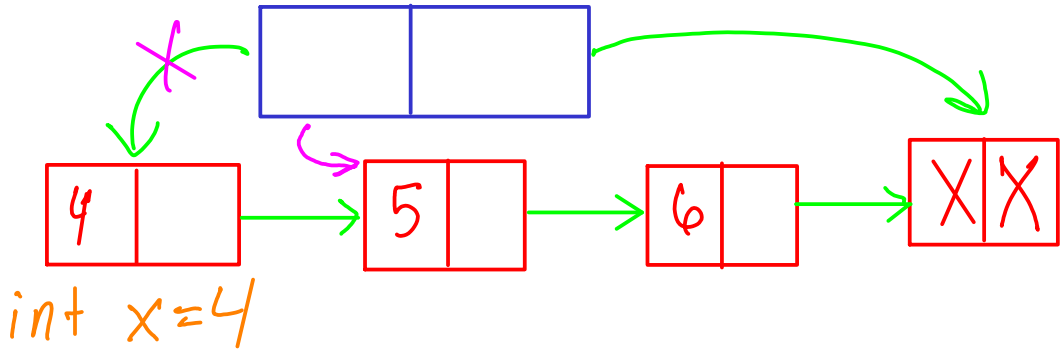
Problem 1

Recall the code for `deq`:

```
int deq(queue Q)
//@requires is_queue(Q);
//@ensures is_queue(Q);
{
    1: int x = Q->front->data;
    2: Q->front = Q->front->next;
    3: return x;
}
```

Suppose `deq(Q)` is called on a queue `Q` that contains before the call, from front to back, `(4, 5, 6)`. Draw the state of the queue after each given line of code. Include an indication of what data the variable `x` holds.

1.



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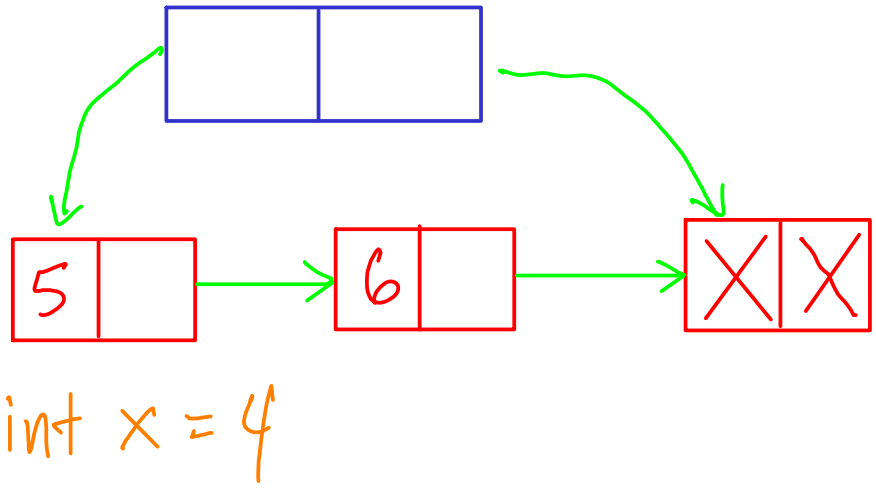


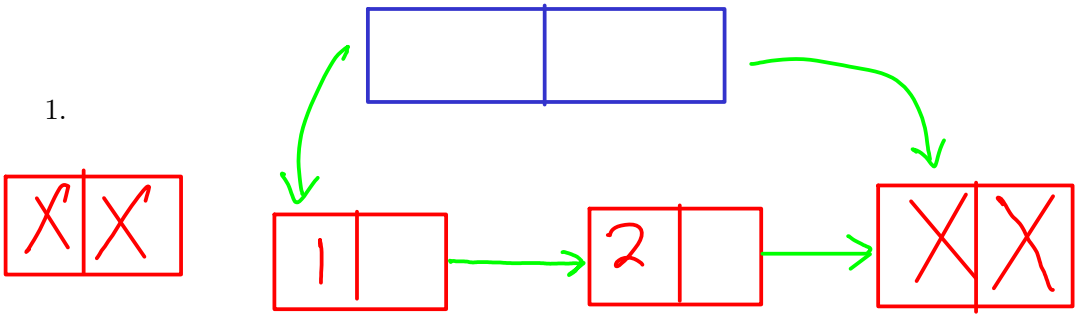
Problem 2

Recall the code for `push`:

```
void push(stack S, int x)
//@requires is_stack(S);
//@ensures is_stack(S);
{
    1: list *l = alloc(struct list_node);
    2: l->data = x;
    3: l->next = S->top;
    4: S->top = l;
}
```

Suppose `push(S, 3)` is called on a stack `S` that contains before the call, from top to bottom, `(1, 2)`. On the next page, draw the state of the stack after each given line of code. Include the list struct separately before it has been added to the stack.

1.



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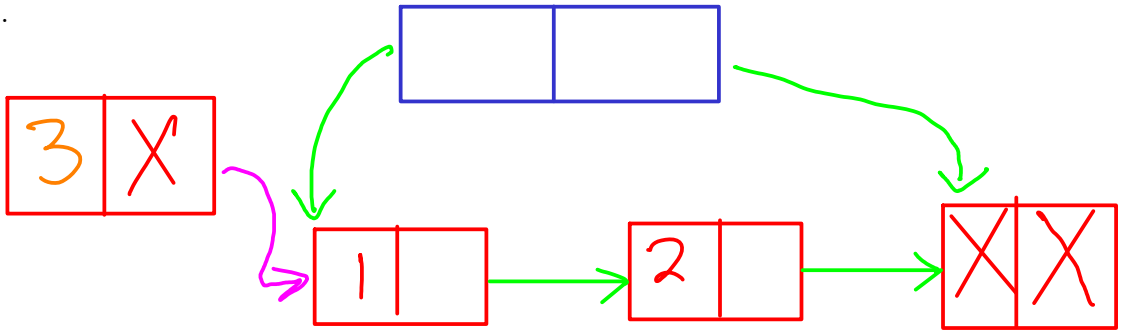

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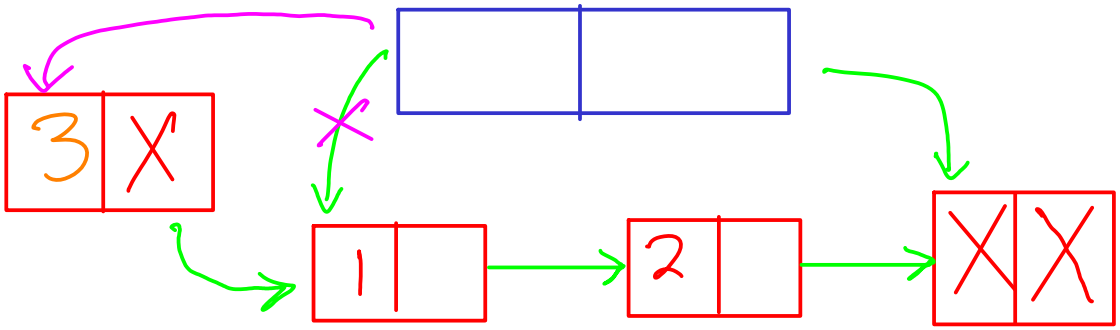

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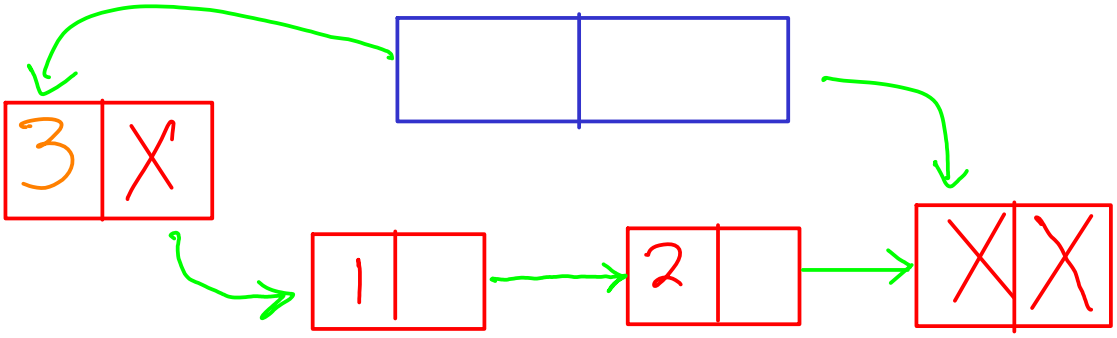


Problem 3

Suppose we want to modify our queue data structure to support the operation `cheat()`. We allow someone to cheat by cutting in line to a position directly after their friend if they know someone in the line. They may only do this if they know a pointer to their friend's node, not just their friend's index in line.

Problem 3a

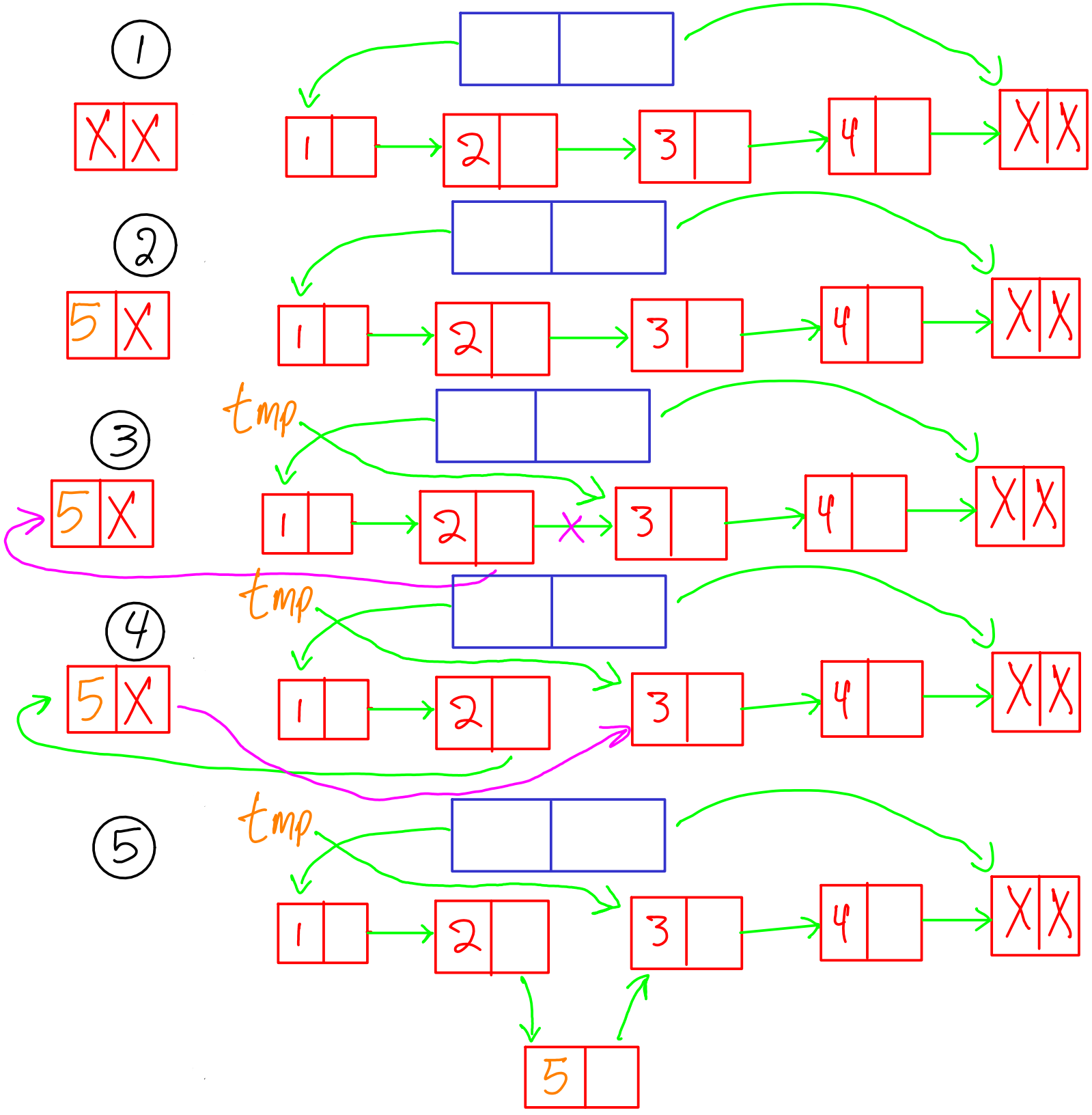
Write a function `void cheat (queue Q, list *friend, int cheater)` that creates a node for the cheater and adds them to the line directly after their friend. It is illegal to call this function if `friend` is not a node of `Q`.
Hint: Solve this problem and Problem 3b in parallel

Problem 3b

Consider a queue `Q` which contains, from front to back, `(1, 2, 3, 4)`, a cheater `5`, and a friend which is a pointer to the node containing `2`. Draw the state of the queue after each line of your `cheat()` function.

Note: There is intentionally more space given than necessary.

```
void cheat (queue Q, list *friend, int cheater)  //@requires friend != NULL;
//@requires is_queue(Q) && is_segment(Q->front,friend) && is_segment(Q->back,friend
//@ensures  is_queue(Q) && friend->next->data == cheater;
{
        list *cheat = alloc(list);
        cheat->data = cheater;
        list *tmp = friend->next;
        friend->next = cheat;
        cheat->next = tmp;









}
```


1
X X
1
2
3
4
X X
2
5 X
1
2
3
4
X X
tmp
3
5 X
1
2
X
3
4
X X
tmp
4
5 X
1
2
3
4
X X
tmp
5
1
2
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4
X X
5