Assuming that the Rotten Potatoes movie controller has at the top:
```ruby
caches_page :log_in_page
  cache_sweeper :movie_sweeper
  caches_action :index, :show
```
and we have the following code:
```ruby
class MovieSweeper < ActionController::Caching::Sweeper
  observe Movie
  def after_save(movie)    ; invalidate ; end
  def after_destroy(movie) ; invalidate ; end
  private
  def invalidate
    expire_action :action => ['index', 'show']
  end
end
```
a) why is this sort of caching useful in improving the performance of Rails apps such as Rotten Potatoes?
b) what is the difference between page caching and action caching?
c) what is a sweeper and how does observe figure into it?
d) how does Ruby make it easier to implement a sweeper than for Java?
2) Consider the following code

```java
0: class Sorter {
1:   int array a;
2:   public bubble()
3:     int i = 0;
4:     int n = (a.length - 1);
5:     while (i < a.length) {
6:       int j = 0;
7:       while (j < n) {
8:         if (a[j] > a[j+1]) {
9:           int t = a[j];
10:          a[j] = a[j+1];
11:          a[j+1] = t;
12:         }
13:       }
14:     }
15: }
16: }
```

In order to do design by contract, we need to specify the postcondition for `bubble`. Actually, there are a few different postconditions of interest here. Using standard logic notation,

a) what would you use as a postcondition to ensure that the elements in the array `a` appear in ascending order when `bubble` completes?

b) what would you use as a postcondition to ensure that the elements in the array `a` after `bubble` has run are the same as they were before `bubble` has run, i.e., that the output is a permutation of the original input.

c) In lines 8 thru 11, the array `a` is indexed. What loop invariant would you use just before line 8 to ensure that the array is never indexed out of its bounds?

d) What loop invariant would you put just after line 7 to help justify the postcondition you gave in a above?

e) What loop invariant would you put just after line 5 to help justify the postcondition you gave in a above?