**Question 1.** For the simplified HTML document with the URL http://a.b.com/index.html, and assuming a web browser that automatically loads JPEG and GIF images, the number of TCP connections opened by the browser to properly display the web page will depend on the mode of HTTP connections used:

(a) Non-persistent HTTP connections: In this mode, the browser will open one TCP connection for each object to be fetched from the web server. Since the web page has 3 objects (a clickable JPEG image and two GIF images), the browser will open **3 TCP connections**, with each connection used to request and receive one object before being closed.

(b) Persistent HTTP connections with non-pipelining: In this mode, the browser will open a single TCP connection for the entire HTTP session and all the objects fetched during that session. However, if the objects are hosted on different servers, the browser would need to open a separate TCP connection for each unique server. In this case, the web page has objects hosted on two unique servers: "a.b.com" for the JPEG and one GIF image, and "x.y.com" for the other GIF image. Therefore, the browser will open **2 TCP connections**, one for each unique server.

(c) Persistent HTTP connections with pipelining: Similar to the persistent mode with non-pipelining, the browser will open **2 TCP connections**, one for each unique server hosting the objects in the web page.

**Question 2.** For the simplified HTML document with the URL http://a.b.com/index.html, and assuming a web browser that automatically loads JPEG and GIF images, the time it takes to display the web page properly (excluding DNS overhead) will depend on the mode of HTTP connections used:

(i) Non-persistent HTTP connections with no parallel TCP connections:
In this scenario, the browser will require 2 RTT initially - 1 RTT for establishing the TCP connection, and 1 RTT to fetch the HTML base file. Then, for each of the 3 objects (1 JPEG image, 2 GIF images), the browser will require an additional 2 RTT - 1 RTT to establish a new TCP connection and 1 RTT to fetch the object. Therefore, the total time to display the web page will be 2 RTT + (3 $\times$ 2 RTT) = **8 RTT**.

(ii) Non-persistent HTTP connections with parallel TCP connections:
In this case, the initial 2 RTT requirement is the same as in the previous scenario. However, since the browser can establish parallel TCP connections, the time to fetch the 3 objects can be shortened. Assuming 2 parallel connections, the time to fetch the 3 objects will be 3 RTT (1 RTT per object, with 2 objects being fetched simultaneously). Therefore, the total time to display the web page will be 2 RTT + 3 RTT = **5 RTT**.

(iii) Persistent HTTP connections with non-pipelining:
With persistent connections, the browser will initially require 4 RTT to establish connections to the two unique servers hosting the objects (2 RTT per server). Then, the browser will require 1 RTT to fetch each of the 3 objects. Therefore, the total time to display the web page will be 4 RTT + 3 RTT = **7 RTT**.

(iv) Persistent HTTP connections with pipelining:
Similar to the persistent mode with non-pipelining, the browser will initially require 4 RTT to establish connections to the two unique servers hosting the objects. However, with pipelining, the browser can fetch all 3 objects in a single RTT. Therefore, the total time to display the web page will be 4 RTT + 1 RTT = **5 RTT**.