Section A: Networks

1. (a) Diagrams for the topologies are given below.
(b)  
• A static address is provided by the NIC and only changes when the hardware is replaced.
• A configurable address comes from a mechanism that allows the user to set a physical address, either manually via switches or electronically via EPROM or similar.
• A dynamic address comes from a mechanism whereby the station either chooses a physical address (not in use elsewhere) or is allocated a physical address by a controlling station.

(c) The standard specifies that Ethernet frames are transmitted using Manchester Encoding, which uses the fact that hardware can detect a change in voltage more easily than a fixed value, e.g. RS-232. Technically, the hardware is edge triggered, with the changes known as rising or falling edges. The sender transmits a falling edge to encode a 0 and a rising edge to encode a 1, as illustrated below.

The voltage change that encodes a bit occurs exactly half-way through the time slot. Exactly half-way through the first time slot, the voltage becomes positive (+0.85 v) to encode a 1. Similarly, exactly half-way through the second time slot, the voltage becomes negative (-0.85 v) to encode a 0. If two contiguous bits have the same value, an additional change in voltage occurs at the edge of the time slot.

Manchester Encoding uses a preamble to allow for synchronisation. The preamble consists of 64 alternating 1s and 0s sent before the frame. These produce a square wave with transitions exactly in the middle of each slot. Receiving hardware uses the preamble to synchronise with the time slots. The last two bits of the preamble are both 1s to signal the end of the preamble.

(d) The structure of an Ethernet frame is given below.
(e) All computers attached to the Ethernet use CSMA/CD to co-ordinate their activities. A computer wishing to transmit checks for electrical activity on the cable. This activity is informally called a carrier. If there is no carrier, the computer can transmit. If a carrier is present, the computer waits for the sender to finish before proceeding. However, it is possible for two or more computers to detect the lack of carrier and start transmission simultaneously. The signals travel at approximately 70% of the speed of light and interfere with one another. This interference is called a collision. A sending computer monitors the signal on the cable and if it differs from the signal it is sending, then a collision has occurred and the computer stops transmitting.

Following a collision, a computer waits for the cable to become idle before retransmitting. However, if the computers start transmitting as soon as the cable becomes free, another collision will occur. Ethernet requires each computer to delay after a collision. The standard specifies a maximum delay, d, and requires each computer to choose a random delay less than d. In this case, the computer choosing the shortest delay will transmit first.

If subsequent collisions still occur, the computers double the maximum delay (2d, 4d, ...) until the range is large enough for one computer to choose a short delay and transmit without a collision. This technique is called binary exponential backoff.

(f) A bridge is an electronic device connecting two LAN segments that uses conventional interfaces and therefore handles complete frames. The bridge listens to each segment in promiscuous mode. When it receives a frame, it verifies that it arrived intact and forwards it to the other segment if necessary. Thus, two LAN segments connected via a bridge behave like a single LAN.

Bridges are popular because they help isolate problems. They only forward complete, correct frames and not collisions or electrical interference. In addition, a bridge performs frame filtering - it only forwards frames if necessary. It uses the source addresses to build up a table of computers attached to each segment.

The principle disadvantage is cost, compared with the cost of repeaters.
2. (a) The five classes are given below.

<table>
<thead>
<tr>
<th>Class A</th>
<th>prefix</th>
<th>suffix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class B</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Class C</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Class D</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Class E</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

(b) 128.10.0.0/16

(c) 212.159.43.0/30
   - 212.159.43.0 Network
   - 212.159.43.1 Outward
   - 212.159.43.2 Outward
   - 212.159.43.3 Broadcast

(d) To fragment a datagram, a host or router uses the MTU and the datagram header size to calculate how many fragments are required (they must be in multiples of 8 octets).

Then the header of the original datagram is copied into the headers of each of the fragments. The following fields change.

- TOTAL LENGTH to reflect the shorter size.
- MORE flag in all but the last fragment.
- FRAGMENT OFFSET to reflect the position of the fragment within the original datagram.
- HEADER CHECKSUM!
3. (a)  
- Connection-oriented. An application requests a connection, and then uses it for data transfer.
- Point-to-point communication. Each TCP connection has exactly two end points.
- Reliability. TCP guarantees that the data sent across the connection will be delivered exactly as sent, without missing or duplicate data.
- Full-duplex connection. A TCP connection allows data to flow in either direction at any time.
- Stream interface. TCP allows an application to send a continuous stream of octets across the connection.
- Reliable startup. TCP requires that two applications must agree to the new connection before it is established. Packets used in previous connections will not appear or otherwise interfere with the new connection.
- Graceful shutdown. An application can open a connection, send data, then shut down the connection. TCP guarantees to deliver all the data reliably before closing the connection.

(b) Connections are established by means of a three-way handshake. One side executes a CONNECT primitive, specifying the destination IP address, destination port, window size, and optionally some user data. This is delivered in a TCP segment with the SYN flag on, the ACK flag off, and an Initial Sequence Number (ISN) which is randomly chosen. This is illustrated below.

In (a), host 1 opens the connection with an ISN of x. Host 2 has previously performed a LISTEN primitive on the appropriate port. It accepts the connect request by sending a
TCP segment which acknowledges host 1’s request (ACK flag on and the ACKNOWLEDGEMENT NUMBER set to x+1) and its own connection request (SYN flag on with an ISN of y). Host 1 acknowledges this request. Note that the SYN flag consumes one byte of sequence space so that it can be acknowledged unambiguously. (4 marks)

(c) The three-way handshake is also used to terminate a connection, as illustrated below.

In this example, host 1 terminates the connection by transmitting a segment with the FIN flag set containing optional data. Host 2 acknowledges this (the FIN flag also consumes one byte of sequence space) and sets its own FIN flag. The third and last segment contains host 1’s acknowledgement of host 2’s FIN flag. (3 marks)

(d) i.  +---------------+  +---------------+
      | A     B     |  | 1000 bytes |
      +---------------+  +---------------+
                | 3001 |
                +---------------+
                | 101  |
                +---------------+
                | 5  0  |ACK|  ?  |  | 1000 bytes |
                +---------------+
                |  ?  |  ?  |  |  ?  |  ?  |
                +---------------+
(ii.) +---------------+  +---------------+
        | B     A     |  | 1000 bytes |
        +---------------+  +---------------+
                | 3001 |
                +---------------+
                | 5  0  |ACK|  ?  |  | 1000 bytes |
                +---------------+
                |  ?  |  ?  |  |  ?  |  ?  |
                +---------------+

(e) • 21 FTP File transfer
• 23 Telnet Remote login
• 25 SMTP E-mail

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Section B: Web technologies

4. (a) An XML entity is a named part of a document, irrespective of structural considerations. Essentially it provides a mechanism for naming and including document fragments. General entities are used in the body of a document, whereas parameter entities are used only within XML DTDs. An example of a general entity declaration is:

```xml
<!ENTITY BBK "Birkbeck College, University of London">
```

A reference to this entity is: &BBK;.

(b) If some element node has been selected by the stylesheet but no rule matches the node, then a default rule is invoked to match all the node’s children. If a text node or attribute node is selected but no rule provided, the corresponding value is output.

(c) By using the GET HTTP method to pass name-value pairs as the query string part of a URI.

5. (a) Every value of an attribute of type ID must be unique within the document, and every value of an attribute of type IDREF must refer to a value of an attribute of type ID.

(b) i. 

```xml
/books/book[count(author) > 2]
```

ii. 

```xml
/book[isbn][not(author[not(first-name)])]
```

(c) A context node must have been defined.

(d) DOM defines an API for HTML and XML documents with the purpose of providing portability across web browsers. DOM defines a logical structure (model) of documents in which a document is modelled as a tree (or forest) of elements. Using DOM, programmers can build documents, navigate their structure and add, modify and delete elements and content. DOM is platform-neutral and language-neutral, with language bindings being defined for a number of programming languages.
6. (a) One possible solution follows:

```xml
<xsl:template match="/cinema">
  <html>
    <body>
      <h1>Films on Saturday</h1>
      <ul>
        <xsl:apply-templates select="film/schedule[day='Sat']"/>
      </ul>
    </body>
  </html>
</xsl:template>

<xsl:template match="schedule">
  <li>
    <xsl:value-of select="../title"/>
    <xsl:for-each select="time">
      <xsl:value-of select="."/>
    </xsl:for-each>
  </li>
</xsl:template>
```

(b) One would want the type of the `day` element to be an enumerated type. This is only possible for attributes, not elements, in a DTD. One would want the times to conform to a standard syntax. Only `PCDATA` is provided by a DTD. Ensuring that each `day` value appears at most once under each `film` also cannot be enforced by a DTD since it cannot constrain occurrences of values.

(14 marks)
7. (a) One possible solution is

```xml
<!ELEMENT wines (wine+) >
<!ELEMENT wine (name, price, vintage?, grape*) >
<!ELEMENT name (#PCDATA) >
<!ELEMENT grape (#PCDATA) >
<!ELEMENT vintage (#PCDATA) >
<!ELEMENT price (#PCDATA) >
<!ATTLIST wine
type (red|white) #REQUIRED>
<!ATTLIST grape
percentage CDATA #IMPLIED>
<!ATTLIST price
quantity (bottle|case) "bottle""
```

(14 marks)

(b) Servers use a combination of filename suffixes/extensions and URL prefixes to decide which processing mechanism to use. The default is that the URL is processed as a request for static content. A URL path beginning with `/servlet/` might indicate that the target is a Java servlet, while one beginning with `/cgi-bin/` might indicate that the target is a CGI script. A URL path where the target filename ends in `.cgi` might indicate that the target is a CGI script, while one ending in `.php` or `.cfm` might indicate template processing with PHP or Cold Fusion.

8. (a) Three functions which are implemented differently are the way in which an empty DOM document is declared (IE uses `ActiveXObject`, Firefox uses `createDocument`), the function for evaluating an XPath expression (IE uses `selectNodes`, Firefox uses `evaluate`), and the function for transforming a document with respect to a stylesheet (IE uses `transformNode` method on XML document, Firefox uses `transformToFragment` method on stylesheet).

(6 marks)

(b) There would be a web page, say `viewDVDs.php` which would use PHP to retrieve the XML file (`DVDs.xml`, say) and transform it into HTML using an XSL stylesheet. (Alternatively the stylesheet could be applied by the browser using a processing instruction in the XML file, but this requires browsers to have this functionality.) The resulting HTML page would list all DVDs in a table, say, and would provide a link to a page, `addDVD.html`, say, for adding a DVD.

The page `addDVD.html` would contain a form for the user to enter information about the new DVD. Clicking on a button on the form would result in the page `addDVDAction.php`, say, being processed. This would contain PHP instructions to add the new DVD to the file `DVDs.xml` by using the DOM to create new elements, add them to the existing DVD collection, and write out the modified file.

(14 marks)