الاسم:_____ **رقم الجلوس:**_____

Problem 1	/10
Problem 2	/10
Problem 3	/15
Problem 4	/15
Problem 5	/25
Problem 6	/30
Total	/100

All answers must be written in a clear, legible, and unambiguous form. Any ambiguous or unclear answers will result in loss of or zero credit

*If the answer is not **100% clear and unambiguous**, then it is considered **wrong***

Irrelevant, unrelated, or additional material in the answers will result in loss of credit
*More than one answer for the same question results in **zero** credit*

There is 5% bonus

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Problem 1 (10%)

Give two advantages for using layered protocols

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Problem 2 (10%)

Which OSI layer handles each of the following?

(a) Delivers raw bits from one peer to the other
(b) Provides end-to-end communication

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Problem 3 (15%)

A system uses ***n***-layer protocol stack. The application generates fixed size messages each of size ***M bits***. The ***i*^th^** layer adds a header of size h_i bits. The throughput as seen by the application is ***A*** **bits/s.** Derive a **concise expression** of the raw bandwidth of the physical channel in **bits/s** in terms of ***A***, ***M***, ***n***, and h_i where $i \in \{1, 2, \ldots, n\}$

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Problem 4 (15%)

Provide a **real life** example for a each of the following

a. Connection oriented protocol

b. Data link layer

c. Connectionless protocol

d. Error detection algorithm

e. Point to multipoint network

f. Transport layer

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Problem 5 (25%)

Consider a set of symbols, each of size ***m*** bits, such that all 2^m symbols are valid. You are required to design a code that **corrects** up to **two** bit errors by adding ***r*** redundant bits to each symbol to generate code words of size $n = m+r$.

a. What is the *minimum* **hamming** distance of the code? (5%)
b. Derive the **minimum** number of code words in terms of ***n***, ***m*** and/or ***r***. (20%)

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Problem 6 (30%)

Consider the unrestricted simplex protocol in a perfect world outlined below

```
/* Protocol 1 (utopia) provides for data transmission in one direction only, from
   sender to receiver.  The communication channel is assumed to be error free,
   and the receiver is assumed to be able to process all the input infinitely quickly.
   Consequently, the sender just sits in a loop pumping data out onto the line as
   fast as it can. */

typedef enum {frame_arrival} event_type;
#include "protocol.h"

void sender1(void)
{
  frame s;                              /* buffer for an outbound frame */
  packet buffer;                        /* buffer for an outbound packet */

  while (true) {
      from_network_layer(&buffer);      /* go get something to send */
      s.info = buffer;                  /* copy it into s for transmission */
      to_physical_layer(&s);            /* send it on its way */
  }                              /       * Tomorrow, and tomorrow, and tomorrow,
                                           Creeps in this petty pace from day to day
                                           To the last syllable of recorded time
                                               - Macbeth, V, v */
}

void receiver1(void)
{
  frame r;
  event_type event;                     /* filled in by wait, but not used here */

  while (true) {
      wait_for_event(&event);           /* only possibility is frame_arrival */
      from_physical_layer(&r);          /* go get the inbound frame */
      to_network_layer(&r.info);        /* pass the data to the network layer */
  }
}
```

Assume that both sender and receiver have **perfect** error **detection** algorithm and that a corrupted packet causes "checksum_err" event. Assume that the **propagation** delay is **greater** than zero. For every sub-question, we will modify or remove one of assumptions. Modify the sender, receiver, or both such that the protocol remains **correct** and as **simple** as possible. If the correct answer is not to modify anything at all, you must mention that. Efficiency is NOT an issue in this problem.

a. Only the **reverse** channel from the receiver to the sender is noisy. Hence packets from the receiver to the sender may be corrupted or lost.
b. Only the **forward** channel from the sender to the receiver is noisy. Hence packets from the sender to the receiver may be corrupted or lost
c. The transmitter has finite buffer and CPU power

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d. The only error that can occur is packet duplication on the **forward** channel. That is, a single packet sent by the transmitter **may** be duplicated and arrive as **two consecutive identical** packets at the receiver.
e. The only error that can occur is packet duplication on the **reverse** channel. That is, a single packet sent by the receiver **may** be duplicated and arrive as **two consecutive identical** packets at the sender.

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