Applied IT Engineer Examination (Afternoon)

Questions must be answered in accordance with the following:

Question Nos.	Q1	Q2-Q7
Question Selection	Compulsory	Select 5 of 6
Examination Time	13:30 - 16:00 (150 minutes)	

Instructions:

1. Use pencils only. If you need to change an answer, erase your previous answer completely and neatly.   Wipe away any eraser debris.

2. Fill in the answer sheet.
   Do not write on the answer sheet outside of the prescribed places.

   (1) **Examinee's Number**
   Write your examinee number in the space provided.

   (2) **Date of Birth**
   Write your date of birth (in numbers) exactly as it is printed on your examination admission card.

   (3) **Question selection**
   For Q2 to Q7, circle the question number that you have answered. If you do not circle, your answer will not be graded. If you circled every question number, the first 5 questions will be graded.

   (4) **Answers**
   Write each answer in the space specified for that question.
   Write your answers clearly and neatly.   Illegible answers may lower your score.

Q1. Read the following description of programs for solving the knapsack problem using the technique of dynamic programming, and then answer Subquestions 1 throught 3.

The knapsack problem is a problem in cominatorial optimaztion. Suppose there are different types of items. Each item has a weight and a value, and items of the same type all have the same weight and the same value. The problem is to determine the number of each type of items to include in a collection so that the total weight of the collection does not exceed a given limit and the total value is as large as poissble. Its name is derived from a problem faced by someone who has only a fixed-size knapsack and must fill it with the most valuable items.

Suppose, for example, we have four items as shown in Table 1. Note that here the number of items available is one for every type. Now the problem reduces to deciding which items, or equivalently which types of items, to pick, and there is no need to consider how many. If the weight limit is 10, then the optimal choice is the items 1 and 3, yielding the total value of $46. A knapsack problem of this type where there is one item of each type is called a 0–1 knapsack problem.

Table 1: Sample Items

Item Type	Weight	Value
1	6	$30
2	3	$14
3	4	$16
4	2	$9

[Program Description]
Variables used in the program include those shown in Table 2.

Table 2: Variables Used

Name	Description
N	The number of item types
Wmax	The maximum total weight allowed
W	An array storing the weight of an item of each type. The subscript range is between 1 and N, inclusive.
V	An array storing the value of an item of each type. The subscript range is between 1 and N, inclusive.
K	An array with the subscript range between 0 and Wmax, inclusive. K[w] is the value of the best filling for a knapsack of weight capacity w. All elements of K are initialized to 0.

The program for finding the best filling based on dynamic programming proceeds in the following manner.

Step 1 Set t = 1.

Step 2 Starting form w=Wmax and working down toward w=0, compute K[w]'s under the condition that only the items of types 1 through t are available. In the t-th stage, K[w] is updated by setting it to the maximum of K[w] and K[w − W[t]] + V[t] from the previous stage

Step 3 Increment t by 1. If t is less than or equal to N, jump to Step 2. Otherwise, the program has found the values of the best filling for a knapsack of weight capacity between 0 and Wmax where all item types 1 through N are available.

[0-1 knapsack problem]

Program 1 below finds the value of the best filling for a 0-1 knapsack problem.

Note that the pseudo-language used here allows a `for` statement with the "`downto`" construct, in addition to the familiar "`to`" construct. With the `downto` construct, the loop control variable is decremented by one after each iteration.

Program 1

```
Integer: N, WMax, W[N], V[N], K[Wmax+1], w, t;
for w = 0 to WMax:
       A      ;
for t = 1 to N:
    for w = WMax downto      B     :
        if K[w-W[t]] +      C      > K[w]:
            K[w] = K[w-W[t]] +      C     ;
```

[Unbounded knapsack problem]

In the unbounded knapsack problem, the number of items available for each item type is unlimited. Program 2 finds the value of the best filling for a bounded knapsack problem.

Note that the blanks A and C contain the same expression as the blanks A and C in Program 1.

Program 2

```
Integer: N, WMax, W[N], V[N], K[Wmax+1], w, t, q, Qmax;
for w = 0 to WMax:
    [   A   ] ;
 for t = 1 to N:
    QMax = [   D   ] ;
    for q = 1 to QMax:
        for w = WMax downto [   E   ] :
            if K[w-W[t]] + [   C   ] > K[w]:
                K[w] = K[w-W[t]] + [   C   ] ;
```

Program 2 finds the value of the best filling, but does not tell us how the best filling can be attained, that is, how many items of each type to pick. Program 3 extends Program 2 and stores the contents of the best filling in a two-dimensional array QT. The first subscript of QT has the range between 0 and Wmax, and the second subscript between 1 and N. QT[w][t] stores the number of items of type t to be included in the best filling for a knapsack with the weight capacity w.

Note that blanks A, C, D and E contain the same expressions as the corresponding blanks in Programs 1 and 2.

Program 3

```
Integer: N, WMax, W[N], V[N], K[Wmax+1], w, t, q, QMax,
         QT[Wmax+1][N], t1;
for w = 0 to WMax:
    [ A ] ;
    for t = 1 to N:
        Q[w][t] = 0;
for t = 1 to N:
    QMax = [ D ] ;
    for q = 1 to QMax:
        for w = WMax downto [ E ] :
            if K[w-W[t]] + [ C ] > K[w]:
                K[w] = K[w-W[t]] + [ C ] ;
                QT[w][t] = [ F ] + 1;
                for t1 from 1 to t-1:
                    QT[w][t1] = [ G ] ;
```

Subquestion 1

Fill in the blanks [A] through [C] in Program 1 with appropriate expressions.

Subquestion 2

Fill the blanks [D] and [E] in Program 2 with appropriate expressions.

Subquestion 3

Fill the blanks [F] and [G] in Program 3 with appropriate expressions.

Q2. Read the following description concerning the configuration of a Web system, and then answer Subquestions 1 through 3.

Company *J* constructs a new Web system (hereinafter referred to as the system) for Bank *K*. The system needs to be accessible to users via the Internet 24 hours a day. To meet this need, the security and the availability requirements described below have been posed as non-functional requirements.
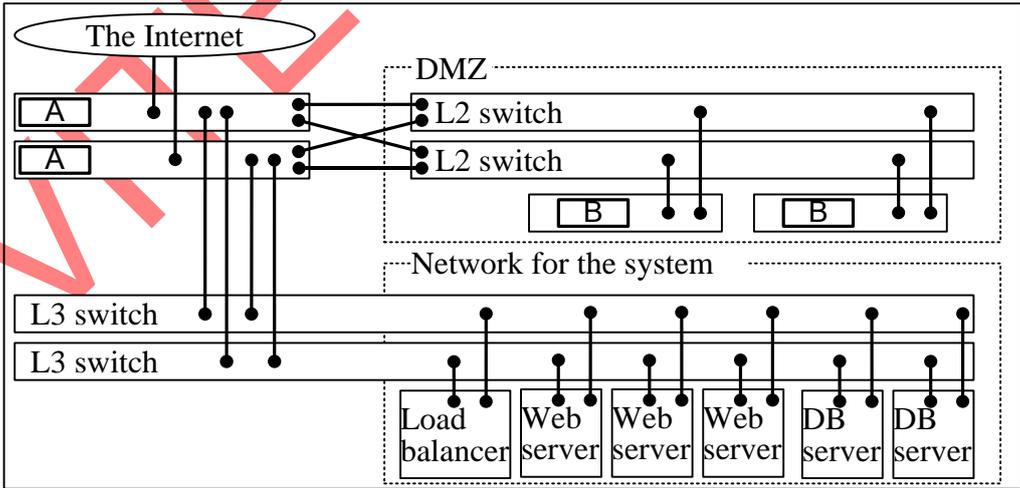
[Security requirements]
Users must not be allowed to connect directly to the business servers (Web servers and DB servers) of the system via the Internet. The system must be equipped with a DMZ, and requests from users are first received by devices within the DMZ and then forwarded to appropriate devices. Only HTTP and HTTPS must be allowed as protocols for handling user requests.

[Availability requirement]
The hardware availability of the entire system must be *four nines* (availability of 99.99% or more).

For a system that meets the above requirements, the configuration shown in the figure below is considered. Each request from users is directed to one of the Web servers by the load balancer. The Web server then responds to the request by using DB servers.

L2 switch: Layer 2 switch
L3 switch: Layer 3 switch

Figure 1: Configuration of the system

The table below shows the reliability of the devices used in the system.　When two (2) or more units of the same device are used, the device as a whole is considered to be operational if any of the units is operational.

Table 1: Reliability of the devices used

Device name	MTBF	MTTR	Availability (single unit)	Number of units used
A	1 year	12 hours	99.86%	2
B	1 year	12 hours	99.86%	2
L2 switch	1 year	12 hours	99.86%	2
L3 switch	1 year	12 hours	99.86%	2
Load balancer	2 years	12 hours	99.93%	1
Web server	1 year	24 hours	99.73%	3
DB server	2 years	C hours	99.86%	2

Subquestion 1

The devices [A] and [B] in the figure and table are necessary to meet the security requirements.　From the answer group below, select the appropriate device names.

Answer group:

  a) IDS   b) RADIUS server
  c) VPN device   d) Firewall
  e) Proxy server   f) Reverse proxy

Subquestion 2

Fill in the blank [C] in the table with the appropriate value.　Round the value down to the integer.　Suppose that one year is 365 days long.

Subquestion 3

Answer (1) through (3) below about the availability of the system.
(1) To meet the requested availability requirement, at most how many minutes of system downtime due to hardware failure may be allowed per year?　Round the value down to the integer.　Suppose that one year is 365 days long.

(2) Let the availability of a single unit of $\boxed{\quad A \quad}$, $\boxed{\quad B \quad}$, L2 switch, L3 switch, load balancer, Web server, and DB server in the figure and the table be p[1], p[2], p[3], p[4], p[5], p[6], and p[7], respectively, and let the number of units of each of these devices be n[1], n[2], n[3], n[4], n[5], n[6], and n[7], respectively. From the answer group below, select the expression that represents the system's overall availability.

Here, $\sum_{i=1}^{7} f(i)$ signifies f(1)+f(2)+…+f(7), and $\prod_{i=1}^{7} f(i)$ signifies f(1)×f(2)×…×f(7).

Answer group:

a) $\sum_{i=1}^{7}(1 - p[i]^{n[i]})$

b) $\sum_{i=1}^{7}(1 - p[i])^{n[i]}$

c) $\sum_{i=1}^{7}(1 - (1 - p[i])^{n[i]})$

d) $\prod_{i=1}^{7}(1 - p[i]^{n[i]})$

e) $\prod_{i=1}^{7}(1 - p[i])^{n[i]}$

f) $\prod_{i=1}^{7}(1 - (1 - p[i])^{n[i]})$

(3) From the answer group below, select the appropriate description concerning the fulfillment of the availability requirement.

Answer group:

a) The device configuration shown in the figure and the table meets the availability requirement.

b) Although the device configuration shown in the figure and the table does not meet the availability requirement, it can be met by adding a Web server and a DB server.

c) Although the device configuration shown in the figure and the table does not meet the availability requirement, it can be met by adding a Web server.

d) Although the device configuration shown in the figure and the table does not meet the availability requirement, it can be met by adding a load balancer.

Q3.   Read the following description concerning the configuration of a wireless LAN, and then answer Subquestions 1 through 4.

Company *P* plans to change the workplace of the sales department to a free-address layout in which unoccupied desks can be used freely.   The sales department has about 40 employees working on a single floor, which measures 30 meters by 15 meters.   The floor is divided into 4 blocks, as shown in Figure 1, and desks are placed in each block.   Employees are provided with a laptop PC, and they store their laptop PCs in a cabinet when they go home.   To facilitate the network connection of the laptop PCs in this environment, Company *P* has drafted a plan to install a wireless LAN in addition to the existing wired LAN.
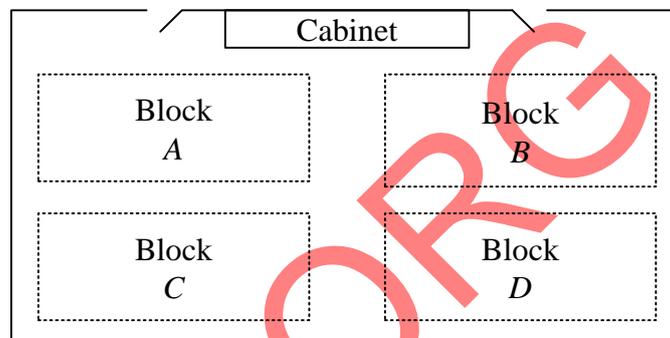

Figure 1: Floor layout

[Outline of the wireless LAN installation plan]
The wireless LAN installation plan is as follows:
  - It is prohibited for employees to add access points.
  - It is prohibited to bring PCs other than the laptop PCs provided to employees into the floor and to connect them to the wireless LAN.
  - Products based on IEEE 802.11, the international standard on wireless LAN, are used, and IEEE 802.11g is chosen as the communication standard.

In IEEE 802.11g,   A   is adopted as the medium access control method.   This control method prevents the occurrence of a collision basically in the following two ways:
(1) A client starts transmission after it confirms that there is no radio wave being transmitted from any other client.

(2) Upon the normal reception of frames from a client, an access point immediately returns | B | and starts communication with the client.

[Wireless LAN installation procedure]

Based on the plan described above, the wireless LAN installation procedure is designed as follows:
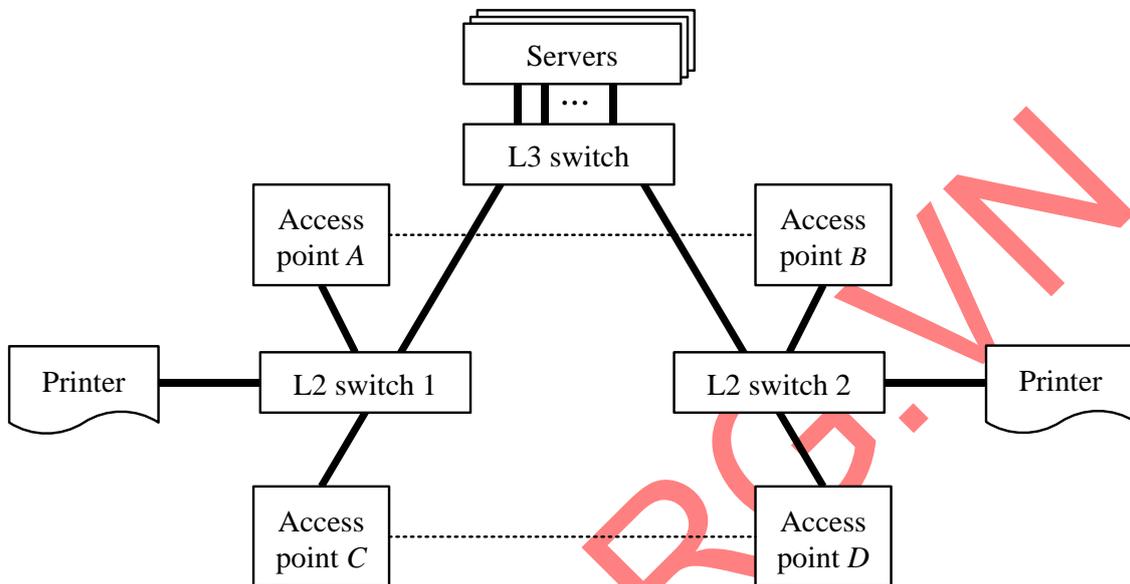
- The existing wired LAN is used as the backbone LAN, and access points are connected to this wired LAN.
- One access point is installed in each block.
- (1) Laptop PCs provided to employees are evenly divided into 4 groups, and a different ESSID is assigned for each group.
- In the existing wired LAN, the DHCP server automatically assigns IP addresses to devices connected to the LAN. Upon a switch to a wireless LAN, a method is adopted whereby (2) the mapping information between MAC addresses and IP addresses is stored manually in the DHCP server and then the IP addresses are determined based on this information for the devices connected to the wired LAN including the access points, and laptop PCs.

[Setting of access points]

- Each access point uses a different channel.
- (3) Each access point is assigned one of the four ESSIDs set on laptop PCs. There is no overlap among the ESSID given to access points.
- The | C | function that hides the ESSIDs to prevent unauthorized connection to the access points and the | D | function that permits communication only when the ESSIDs match are set.

[Redundancy measure]

Considering that printers are connected to the wired LAN, two L2 switches and one L3 switch are used to form the network configuration shown in Figure 2.

Note: Access point *A* represents the access point installed in block *A*.
The same applies to access points *B*, *C*, and *D*.
L2 switch is a layer 2 switch, and L3 switch is a layer 3 switch.

Figure 2: Network configuration

In preparation for a network failure in the wired LAN, network redundancy is implemented by using the access point interconnection function that enables wireless communication between access points and by adopting the spanning tree protocol (hereinafter referred to as the STP) for the switches and the access points.   The STP is used in the following manner:

(1) The L3 switch is chosen as the root bridge.

(2) The root ports (a root port is a port that provides the shortest path to the root bridge from a switch other than the root bridge) and the designated ports (a designated port is a port closest to the root bridge in a path between switches) are selected so that the paths represented by bold lines are used as communication paths in normal operation, and the bridge priorities are set accordingly.   Other ports, to each of which the communication path between access points as indicated by a dotted line is connected, are the blocking ports (a blocking port is a port that is neither a root port nor a designated port and that blocks communication).

(3) Access points *A*, *B*, *C*, and *D* have bridge priorities, higher to lower in the order listed.

Subquestion 1

From the answer group below, select the appropriate term to be inserted in blanks $\boxed{\quad A \quad}$ and $\boxed{\quad B \quad}$ in the description.

Answer group:

a) ACK   b) CSMA/CA   c) CSMA/CD

d) ENQ   e) OSPF   f) SYN

Subquestion 2

(1) Briefly describe the purpose of taking both of the steps mentioned in the underlined parts (1) and (3) in the description.

(2) Briefly describe the purpose of adopting the method mentioned in the underlined part (2) in the description.

Subquestion 3

From the answer group below, select the appropriate term or phrase to be inserted in blanks $\boxed{\quad C \quad}$ and $\boxed{\quad D \quad}$ in the description.

Answer group:

a) denying any-connection   b) ad-hoc mode

c) stealth   d) message authentication

e) routing   f) roaming

Subquestion 4

From the answer group below, select two appropriate descriptions of what can be implemented by setting the STP.

Answer group:

a) If the line between the L3 switch and L2 switch 1 is disconnected, a switchover to the path connecting access points *A* and *B* automatically occurs.

b) If the line between the L3 switch and L2 switch 2 is disconnected, a switchover to the path connecting access points *A* and *B* and the path connecting access points *C* and *D* automatically occurs.

c) If the line between the L3 switch and L2 switch 2 is disconnected, a switchover to the path connecting access points *C* and *D* automatically occurs.

d) The STP provides redundancy for the communication paths between the L3 switch and the two L2 switches to which access points are connected.

e) If the line to which the designated port is connected is disconnected, communication is restored by immediately rerouting traffic to the line to which the blocking port is connected.

Q4. Read the following description of a furniture sales management system, and answer Subquestions 1 through 4.

Company *C* manufactures and sells furniture. Three months ago, Company *C* began operating a sales management system (hereafter referred to as "the system"). The system possesses functions for compiling documents such as invoices with sales details for a customer and sales reports for the internal use. After three months of system operation, a problem is encountered regarding a sales report.

[Problem Encountered, and Check on the E-R Diagram and SQL Statements]
Figure 1 shows a sales report for September 2011, in which a problem was found.

Sales report by furniture type and by corporate client

Output date: October 5, 2011

September 2011 sales by furniture type

Furniture type no.	Furniture type name	Sales (in thousands of dollars)
S01	Storage	60
D01	Desks	40
C01	Chairs	26
C02	Sofas	20
⋮	⋮	⋮
Total		1,198

September 2011 sales by corporate client

Corporate Client No.	Corporate client name	Sales (in thousands of dollars)
C0001	AA Department Store	85
C0003	BB Thrift Store	34
C0008	CC Trading Company	23
C0004	DD Private Prep School	18
C0010	EE Home Center	8
⋮	⋮	⋮
Total		1,200

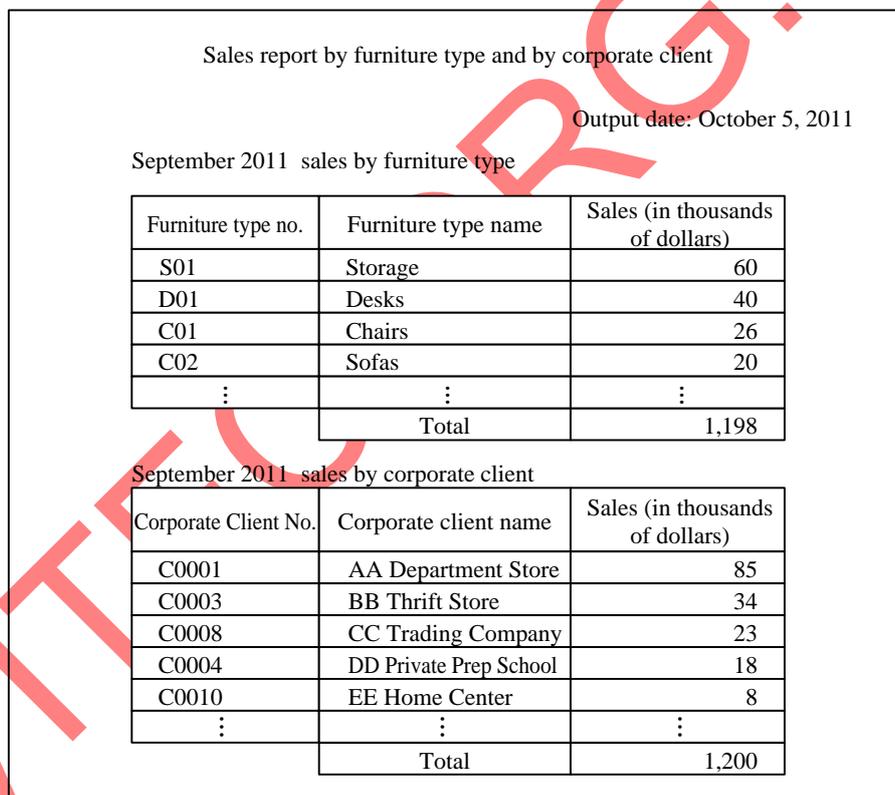**Figure 1: September 2011 sales report by furniture type and by corporate client**

Although the total of corporate client-wise sales and the total of furniture type-wise sales should be equal, the latter turned out to be 2 thousand dollars less than the former.
Mr. *D*, who was assigned to track down the cause of this problem, first decided to check the E-R diagram and the SQL statements used to compile the sales report.

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Figure 2 shows the E-R diagram for the system.

The system manages data using a relational database where tables are defined by appropriate data types, entity names are used as table names and attribute names are used as column names according to the E-R diagram.
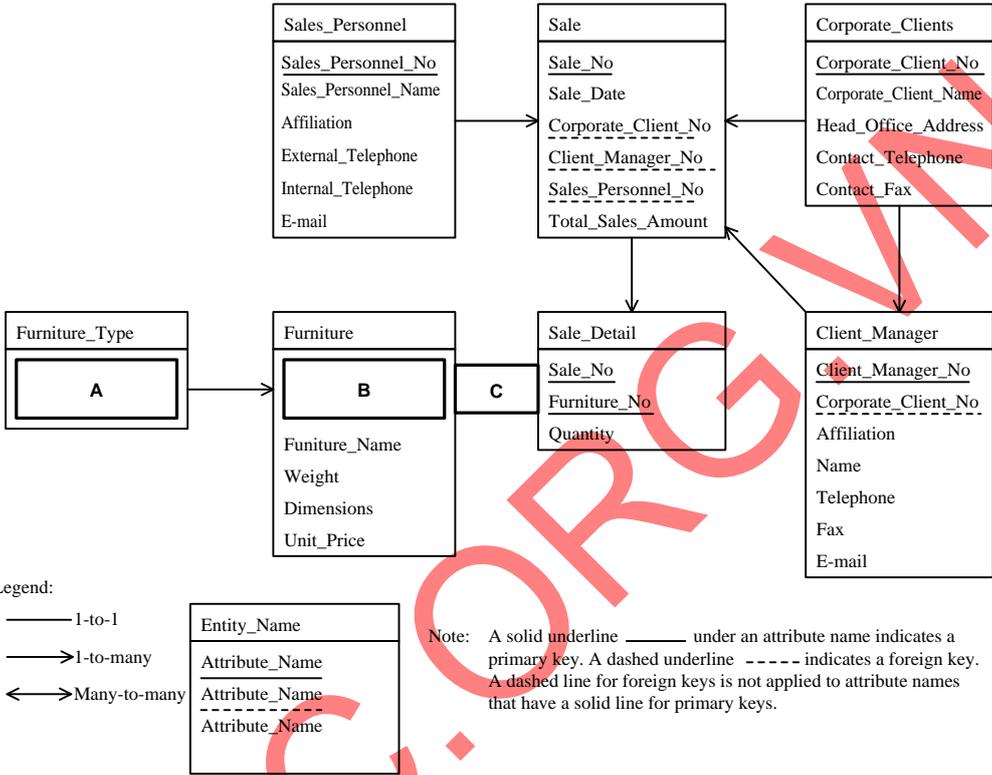

Figure 2: E-R diagram for the system

The two SQL statements used to compile the sales report in Figure 1 are shown below. Note that ":First_Day_of_Given_Month" and ":Last_Day_of_Given_Month" are host variables used to represent the first day and the last day of the month for which a report is to be produced.

- SQL statement for totaling the sales by furniture type (SQL Statement 1)

```
SELECT Furniture.Furniture_Type_No,
    Furniture_Type.Furniture_Type_Name,
      [  D  ] (Furniture.Unit_Price * Sale_Detail.Quantity)
              AS Sale_Record
FROM Sale, Sale_Detail, Furniture, Furniture_Type
WHERE Sale.Sale_Date [  E  ] :Start_Day_for_Given_Month
                        AND :End_Day_for_Given_Month
  AND Sale.Sale_No = Sale_Detail.Sale_No
  AND Sale_Detail.Furniture_No = Furniture.Furniture_No
  AND Furniture.Furniture_Type_No =
                        Furniture_Type.Furniture_Type_No
  [  F  ] Furniture.Furniture_Type_No,
            Furniture_Type.Furniture_Type_Name
ORDER BY Sales_Record DESC
```

- SQL Statement for totaling the sales by corporate client   (SQL Statement 2)

```
SELECT Sale.Corporate_Client_No,
              Corporate_Client.Corporate_Client_Name,
              [  D  ] ( Sale.Total_Sales_Amount )
                     AS Sales_Record
FROM Sale, Corporate_Client
WHERE Sale.Sale_Date [  E  ] :Start_Day_for_Given_Month
                        AND :End_Day_for_Given_Month
  AND Sale.Corporate_Client_No =
            Corporate_Clients.Corporate_Client_No
  [  F  ] Sale.Corporate_Client_No,
              Corporate_Client.Corporate_Client_Name
ORDER BY Sales_Record DESC
```

[Cause Analysis and Investigation]

Mr. *D* investigated whether the cause of the discrepancy in sales report produced by the system could be found in two SQL statements. Since SQL Statement 2 only totals the records collected at the time of sale, the actual total sales should be obtained as long as there is no mistake in the input. In the case of SQL Statement 1, because the accumulated total is based on the current unit price of the furniture, it is possible that a different amount than recorded at the time of sale may be obtained if the unit price at the time of sale differs from its current value. Mr. *D* therefore presumed that the cause might be due to a difference between the unit price at the time of sale and the current unit price.

When Mr. *D* looked into how the unit price of furniture was being set, he noted the following three facts:

• The unit price of furniture is updated almost every quarter, but not periodically. The last time that prices were updated was October 1, 2011.

• Prices are not updated during business hours. The unit price in the table Furniture is updated outside of business hours when the online system is not in operation, on the day before the new prices become effective.

• The sales department has placed a request that they would like to set the unit sales price for each sale. However, at the present time, the unit price cannot be changed depending on customer or on sale.

Based on the above, Mr. *D* concluded that the price update on October 1, 2011 was the cause of the current problem. In order to overcome this problem, the following proposal on a revised data structure was studied.

[Proposal for Maintaining Unit Price Update History]

In order to maintain a unit price update history for each furniture, the attribute "Unit_Price" is deleted from the entity Furniture and an entity Unit_Price_History is added. Figure 3 shows the E-R diagram illustrating the relationship between the newly added entity Unit_Price_History and the entity Furniture.

The blank [B] in Figure 3 contains the same attribute name as the blank [B] in Figure 2.

```
┌─────────────────────────┐          ┌─────────────────────────┐
│ Unit_Price_History      │          │ Furniture               │
├─────────────────────────┤          │ ┌─────────────────────┐ │
│ Furniture_No            │          │ │          B          │ │
│ Effective_Date          │ ◄─────── │ └─────────────────────┘ │
│ Unit_Price              │          │ Furniture_Name          │
└─────────────────────────┘          │ Weight                  │
                                     │ Dimensions              │
                                     └─────────────────────────┘
```
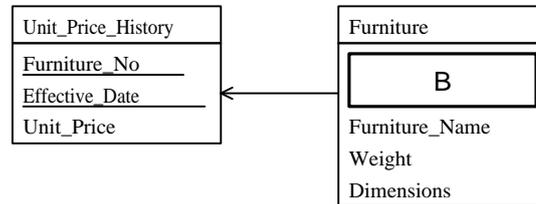
Figure 3: E-R diagram with Unit_Price_History entity added (partial)

In addition, the following proposal was also studied in order to account for not only the current problem, but also the request from the sales department.

[Proposal for Setting Unit Price for Each Sale]
An attribute [G] is added to the entity [H], so that, every time furniture is sold, the sales personnel can set a unit price specifically for that sale.

Subquestion 1

Complete the E-R diagram given in Figure 2 by filling in the blanks [A] through [C] with the appropriate attribute names and relationships between entities.
Indicate the relationship between entities and attribute names according to the legend given in Figure 2.

Subquestion 2

Fill in the blanks [D] through [F] in the above description with the appropriate term or phrase.

Subquestion 3

Shown below is an SQL statement to produce the sale detail when the [Proposal for Maintaining Unit Price Update History] is adopted. Fill in the blanks ☐ I ☐ through ☐ N ☐ in the SQL statement with the appropriate term or expression.

Note that a listing of furniture number, furniture name, quantity, unit price, and subtotal is output for the sale detail list in the ascending order of furniture number. Furthermore, the host variable used to indicate the sale number of a sale to be processed is ":Sale_No".

When referring to a column, the alias for the table name must not be omitted.

```
SELECT HM.Furniture_No, KG.Furniture_Name, HM.Quantity,
        ☐ I ☐ , ☐ J ☐ AS Subtotal
FROM Sale HA, Sale_Detail HM, Furniture KG, Unit_Price_History TN
WHERE ☐ K ☐
  AND HA.Sale_No = HM.Sale_No
  AND HM.Furniture_No = KG.Furniture_No
  AND KG.Furniture_No = TN.Furniture_No
  AND TN.Effective_Date =
                ( SELECT ☐ L ☐
                  FROM Unit_Price_Hisoty TN2
                  WHERE TN2.Furniture_No = ☐ M ☐
                    AND TN2.Effective_Date <= ☐ N ☐ )
ORDER BY HM.Furniture_No
```

Subquestion 4

Fill in the blanks ☐ G ☐ and ☐ H ☐ with the appropriate entity name and the attribute name in the section [Proposal for Setting Unit Price for Each Sale].

Q5. Read the following description concerning the tests in a development process, and then answer Subquestions 1 through 4.

Company *A* is planning to develop an equipment diagnostic system for a manufacturing plant of its customer. The equipment diagnostic system collects data on the temperature, humidity, and vibration of individual equipment in the plant and creates a diagnostic report that includes information such as whether the equipment is normal or abnormal. The equipment diagnostic system consists of a measurement device subsystem and a diagnostic subsystem. Figure 1 shows the DFD of the equipment diagnostic system. Since special-purpose computers that can be attached to equipment are used for the measurement device subsystem, the development of this subsystem is entrusted to Company *B*, the developer of the special-purpose computers. Company *A* develops the diagnostic subsystem.
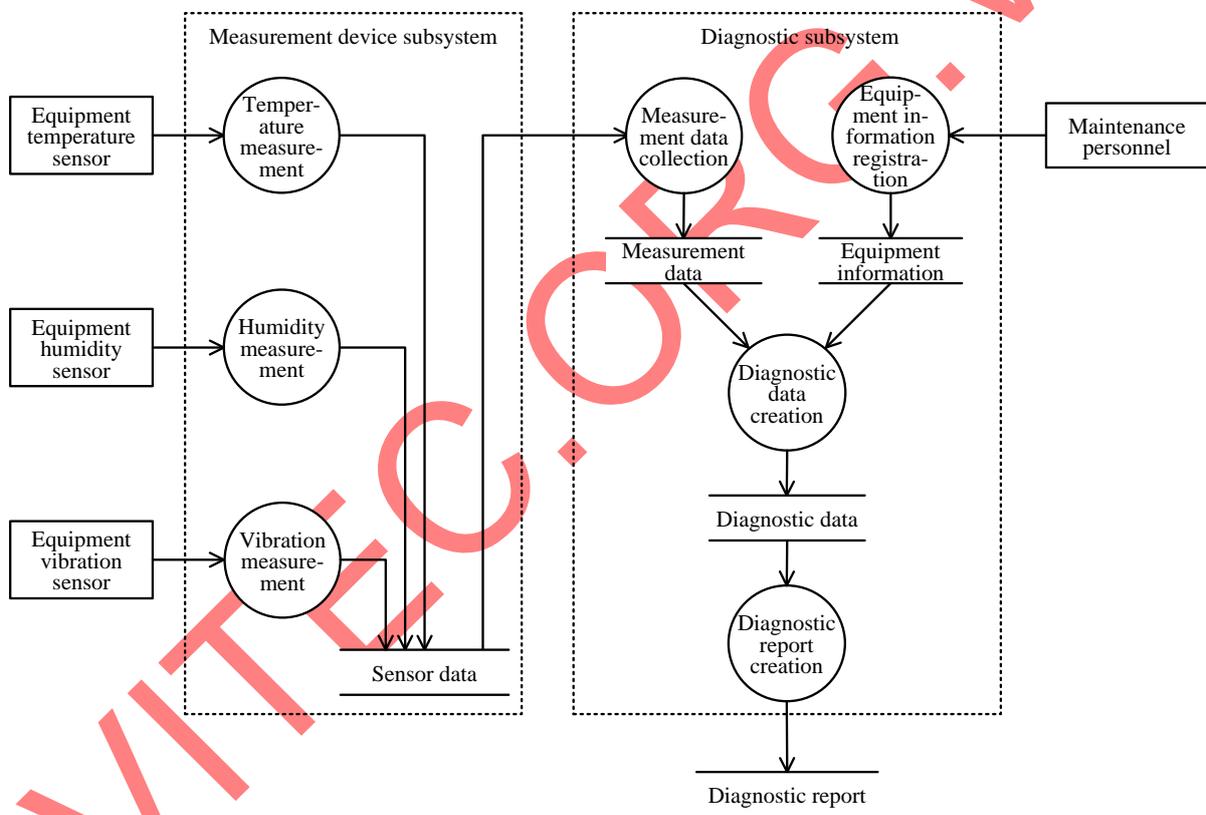
Figure 1: DFD of the equipment diagnostic system

The measurement device subsystem consists of the temperature measurement process, humidity measurement process, and vibration measurement process, and these processes measure the temperature, humidity, and vibration of equipment, respectively, by using the corresponding sensors, and save measurement results as sensor data. The measurement data collection process of the diagnostic subsystem collects the sensor data at regular intervals and accumulates the collected data as measurement data.

Valid sensor data is numeric data that is within a range defined for each type of equipment and sensor, and can be classified into the normal value range where equipment can operate without problems and the abnormal value range where problems may arise.   If there is any saved data that is neither a normal value nor an abnormal value, the measurement data collection process handles it as incorrect data.   One cause of incorrect data is a failure of a sensor.   In order to access the sensor data of the measurement device subsystem and collect the data, the sensor data *read* function provided by Company B needs to be called from the program of the diagnostic subsystem.

The equipment information registration process registers the ranges of normal values and abnormal values of individual equipment as equipment information.   The diagnostic data creation process creates diagnostic data from measurement data and equipment information.   The diagnostic report creation process creates a diagnostic report based on diagnostic data.

Figure 2 shows the schedule of the project for developing the equipment diagnostic system.
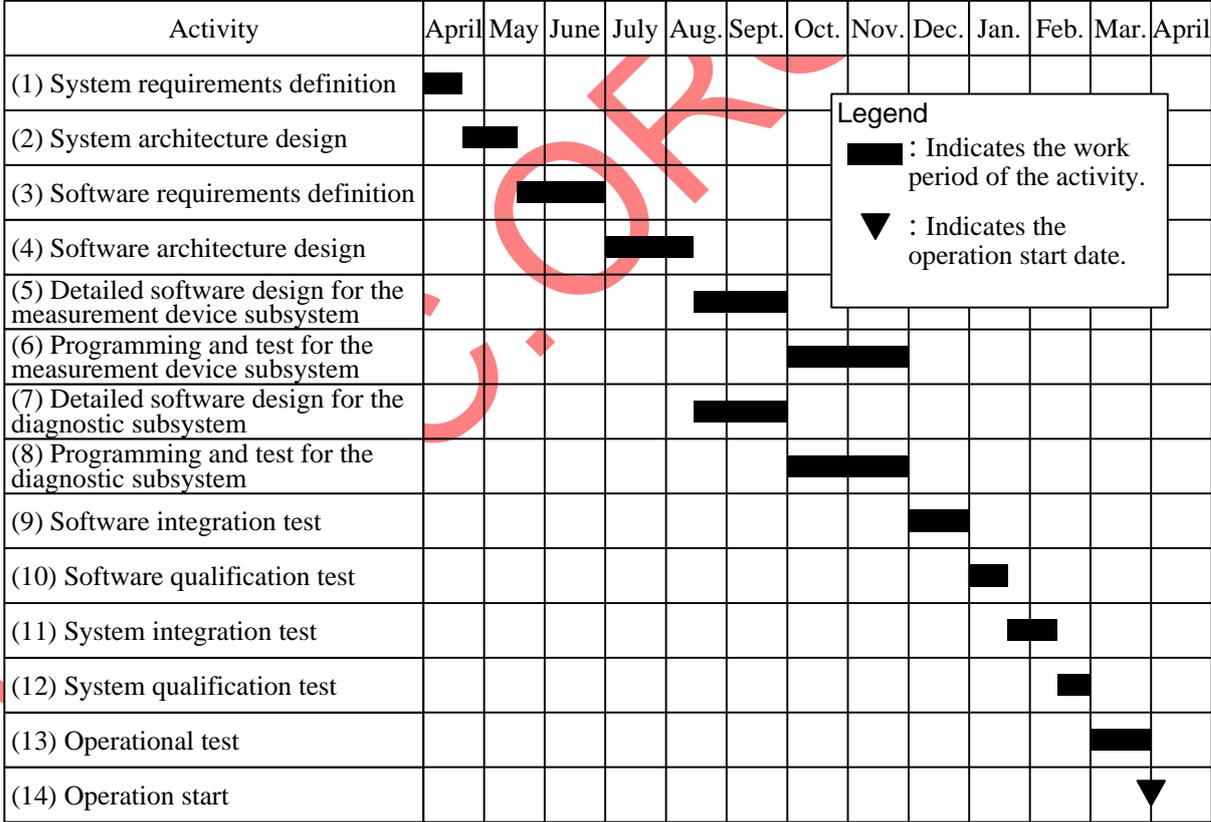
Activity	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April
(1) System requirements definition	■												
(2) System architecture design		■											
(3) Software requirements definition			■										
(4) Software architecture design				■									
(5) Detailed software design for the measurement device subsystem					■								
(6) Programming and test for the measurement device subsystem							■						
(7) Detailed software design for the diagnostic subsystem					■								
(8) Programming and test for the diagnostic subsystem							■						
(9) Software integration test									■				
(10) Software qualification test										■			
(11) System integration test											■		
(12) System qualification test												■	
(13) Operational test													■
(14) Operation start													▼

Legend
■ : Indicates the work period of the activity.
▼ : Indicates the operation start date.

Figure 2: Schedule of the project for developing the equipment diagnostic system

In Figure 2, the operational test is to be performed by the customer and is mainly intended to verify operation in the actual operational environment, verify the initial data, and train maintenance personnel who use the system.

Mr. *C* belongs to the development team of Company *A,* and has been assigned to the test plan development for the equipment diagnostic system.   He is in charge of the test activities (8) through (12) in Figure 2.   First, Mr. *C* determines the activity defining the requirements to be verified and the purpose of the test for each test activity, and summarizes the result as test activity definitions shown in Table 1 below.

Table 1: Test activity definitions

Test activity	Activity defining the requirements to be verified	Purpose of the test
(8) Programming and test for the diagnostic subsystem	A	To verify whether the program of the diagnostic subsystem is implemented according to A
(9) Software integration test	Software architecture design	To verify whether the software of the equipment diagnostic system is implemented according to software architecture design
(10) Software qualification test	B	To verify whether the software of the equipment diagnostic system is implemented according to B
(11) System integration test	Systems architecture design	To verify whether the equipment diagnostic system is implemented according to systems architecture design
(12) System qualification test	C	To verify whether the equipment diagnostic system is implemented according to C

In considering the testing method, Mr. *C* thought it important to verify the data linkage between the subsystems developed by Companies *A* and *B*.   He anticipated that, after Company *A* executed the activity "Programming and test for the diagnostic subsystem" and Company *B* executed the activity "Programming and test for the measurement device subsystem" in parallel, failures could occur due to design inconsistencies or programming errors in the software integration test where the two subsystems are put together for the first time, posing the risk that the activities might be delayed.   Therefore, he thought it necessary to effectively use a stub in   D   .

Also, the system integration test should be based principally on [E]. Specifically, Mr. *C* thought it necessary to perform equivalence class partitioning or [F] to design test cases.

Eventually, the project started as planned, and the system integration test is now in preparation. Mr. *C* reviewed a test case designed by Mr. *D* in charge of the preparation for the system integration test. In equivalence class partitioning, Mr. *D* treated the ranges of normal values and abnormal values of measurement data, specified for individual equipment in the equipment information, as equivalence classes. Mr. *C* thought that this was not satisfactory for a test case, and that he should instruct Mr. *D* to add more equivalence classes.

Subquestion 1

From (1) through (14) in Figure 2, select the appropriate activity to be inserted in each blank [A] through [D] in the table and description.

Subquestion 2

What is the stub that should be prepared for the test of the diagnostic subsystem during the parallel development by Companies *A* and *B*? Answer by using the term or phrase in the description.

Subquestion 3

From the answer groups below, select the appropriate term or phrase to be inserted in each blank [E] and [F] in the description.

Answer group for E:

    a) operational test   b) parity check

    c) black box test   d) white box test

    e) module test

Answer group for F:

    a) boundary value analysis   b) condition coverage test

    c) static test   d) big bang test

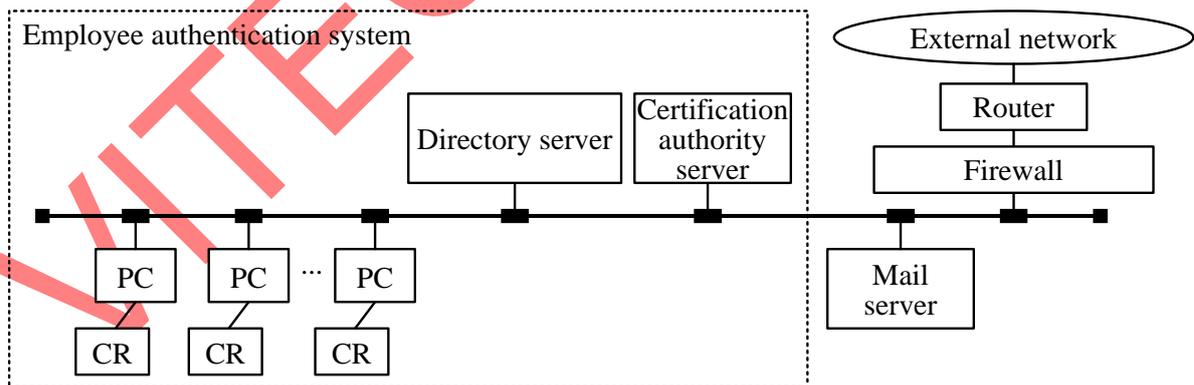   e) statement coverage test

Subquestion 4

What is the equivalence class that Mr. *D* should add? Answer by using the term or phrase in the description.

Q6. Read the following description concerning an employee authentication system using a public key infrastructure, and then answer Subquestions 1 through 4.

Company *X*, engaged in sales business, operates an employee authentication system (hereinafter this system) using a public key infrastructure to ensure that personal information such as customer information and highly confidential information related to the sales business are handled securely in e-mails used for internal operations. Figure 1 shows an outline of the company's internal system including this system.

[Outline of this system]
 (1) This system consists of a directory server, a certification authority server, and PCs and IC employee cards (hereinafter "IC cards") of individual employees.
 (2) The directory server is used to register and search for information such as public key certificates and e-mail addresses of employees.
 (3) This system uses a private certification authority.
 (4) Each IC card stores an employee's private key, public key certificate, and PIN (Personal Identification Number). When using this system, the employee inserts his or her IC card into the IC card reader of the PC and enters the PIN, which is the password for the IC card.
 (5) In the PC, software (hereinafter the PC subsystem) that provides the authentication function, encryption function, and e-mail client function for this system is installed.

Note: CR represents an IC card reader.

Figure 1: Outline of the internal system

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[Issuing a new IC card]

The following describes the procedure in which the system administrator issues a new IC card to employee *A*.

(1) The system administrator generates a pair of [A] and [B] by using the certification authority server.

(2) The certification authority server signs the information that associates [B] with the employee name, effective period, etc. by using [C] in order to generate [D].

(3) The certification authority server registers [D] in the directory server.

(4) The certification authority server records the generated [A] and [D], and the PIN that has been submitted in advance, on a new IC card.

(5) The system administrator gives the IC card to employee *A*.

[Sending and receiving an e-mail message]

Shown below is the procedure in which employee *A* sends employee *B* a message containing encrypted business information with a digital signature and employee *B* receives this message.

<<Sender >>

(1) Employee *A* logs in to the PC subsystem by inserting his or her IC card into the IC card reader of the PC and entering his or her PIN.

(2) Employee *A* creates an e-mail message that he or she wants to send to employee *B* and then requests the PC subsystem to process that message.

(3) The PC subsystem calculates the hash value of the created message and encrypts that hash value with employee *A*'s private key to generate a digital signature.

(4) The PC subsystem obtains employee *B*'s public key certificate from the directory server and checks its validity.

(5) The PC subsystem encrypts the created message and the digital signature by using employee *B*'s public key attached to his or her public key certificate and sends the message to employee *B*.

<<Receiver >>

(1) Employee *B* logs in to the PC subsystem by inserting his or her IC card into the IC card reader of the PC and entering his or her PIN.

(2) [E]

(3) [F]

(4) [G]

Subquestion 1

From the answer group below, select the appropriate phrase to be inserted in each blank [A] through [D] in the description concerning the process for issuing a new IC card.

Answer group:

- a) the public key of the system administrator
- b) the public key certificate of the system administrator
- c) the private key of the system administrator
- d) the common key of employee *A* and the system administrator
- e) the public key of employee *A*
- f) the public key certificate of employee *A*
- g) the private key of employee *A*
- h) the common key of the certification authority and system administrator
- i) the common key of the certification authority and employee *A*
- j) the public key of the certification authority
- k) the public key certificate of the certification authority
- l) the private key of the certification authority

Subquestion 2

From the answer group below, select the appropriate sentence to be inserted in each blank [E] through [G] in the description concerning the procedure after receiving an e-mail message.

Answer group:

- a) The PC subsystem obtains employee *A*'s public key certificate from the directory server and checks its validity.
- b) The PC subsystem receives the message and the digital signature encrypted with employee *B*'s public key, and decrypts them by using employee *B*'s private key.
- c) The PC subsystem calculates the hash value of the decrypted message and compares it against the hash value decrypted from the digital signature by using employee *A*'s public key attached to employee *A*'s public key certificate in order to check whether the message has been altered or not.

Subquestion 3

There is a possibility that an event may occur that cannot be prevented by the functions of this system.   From the answer group below, select all the events that apply.

Answer group:

    a)   Employee *A* pretends to be employee *B* by using employee *A*'s IC card and PIN.

    b)   Employee *A* loses his or her IC card.

    c)   Employee *C* decrypts the encrypted message from employee *A* intended for employee *B*.

    d)   Employee *A* denies the message with a digital signature that employee *A* has sent to employee *B*.

    e)   Employee *B* alters the contents of the message with a digital signature that employee *A* has sent to employee *B*.

    f)   Employee *A* fakes the digital signature of employee *B*.

Subquestion 4

E-mail can also be sent from the internal system to the outside of the company.   In that case, if, for example, the following procedure is used to send a message created by employee *A* to receiver *D*, who is not an employee of Company *X*, receiver *D* cannot verify that the received message is from employee *A*.   Describe the reason briefly.

[Sending and receiving an e-mail message]
<<Sending side>>

(1)   Employee *A* logs in to the PC subsystem by inserting his or her IC card into the IC card reader of the PC and entering his or her PIN.

(2)   Employee *A* creates an e-mail message that he or she wants to send to receiver *D*, who is not an employee of Company *X*, and then requests the PC subsystem to process that message.

(3)   The PC subsystem calculates the hash value of the created message and encrypts that hash value with employee *A*'s private key to generate a digital signature.

(4)   The PC subsystem sends the created message and the signature to receiver *D*.

Q7. Read the following description concerning the management of a software development project, and then answer Subquestions 1 through 5.

[Project Outline]

Company *K* has been commissioned to develop a computer-aided design (CAD) software to be used in designing various parts of model aircrafts. To design a part, first, a two-dimensional (2D) drawing of the part is created using the software. Then, after specifying the thickness of the part, the software will generate a three-dimensional (3D) representation of the part. The software also supports basic instructions for describing how the parts will be assembled together.

During the initial design phase, it was determined that the software can be partitioned into four (4) modules: 2D graphics, 3D graphics, Import/export, and User interface. These modules are intended to be designed and developed independently. After all the modules are completed, they will be integrated to form the final software.

The development project is divided into eight (8) tasks. The total development period is eight (8) months. Table 1 shows the planned project schedule. The Integration task cannot start unless all four (4) modules are ready. The Integration test can only begin after Integration, and the User acceptance test will be performed after the Integration test is finished. A total budget of $1,300,000 is allocated for the project. Table 2 shows the budget allocated for each task.

Table 1: Project Schedule

1st month	2nd month	3rd month	4th month	5th month	6th month	7th month	8th month
2D graphics module →							
	3D graphics module →						
Import/export module →							
User interface module →			Integration →		Integration test →		User acceptance test →
		Documentation →					

Table 2: Project Budget Allocation

Task	Budget
2D graphics module	$150,000
3D graphics module	$200,000
Import/export module	$100,000
User interface module	$150,000
Documentation	$100,000
Integration	$100,000
Integration test	$300,000
User acceptance test	$200,000
Total	$1,300,000

For tasks that span multiple months, completion targets were assigned for each month. Table 3 shows the target completion rate by the end of each month for each task. These targets also represent the portion of the allocated budget to be spent for the task.

Table 3: Completion Targets

Task	1st	2nd	3rd	4th	5th	6th	7th	8th
2D graphics module	30%	70%	100%					
3D graphics module	25%	50%	75%	100%				
Import/export module	60%	100%						
User interface module	35%	65%	100%					
Documentation			50%	100%				
Integration					100%			
Integration test						50%	100%	
User acceptance test								100%

One of the important roles of a project manager is to monitor and control the project schedule and cost. Earned Value Management (EVM) is one of the techniques to quantitatively measure and assess the project's performance, and make the necessary adjustments or countermeasures. The data collected from EVM can also be used to make more reasonable estimates in the future.

At the end of every month, each team reports to the project manager the completion status of the task and the cumulative amount of budget spent for it. As the project manager, you are responsible for determining the overall status of the project in terms of schedule and cost.

Table 4 shows the status report for the 1st month of the project.

Table 4: Status Report for the 1st Month

Task	Completion Status	Actual Cost
2D graphics module	20%	$40,000
3D graphics module	30%	$70,000
Import/export module	50%	$40,000
User interface module	45%	$50,000

Subquestion 1

From the answer group below, select the the correct pair of formula to compute the Cost Performance Index and Schedule Performance Index in Earned Value Management.

CPI = Cost Performance Index

SPI = Schedule Performance Index

EV = Earned Value

PV = Planned Value

AC = Actual Cost

Answer group:

    a) CPI = AC/EV

       SPI = PV/EV

    b) CPI = EV/AC

       SPI = EV/PV

    c) CPI = EV/PV

       SPI = EV/AC

    d) CPI = PV/EV

       SPI = AC/EV

Subquestion 2

From the answer group below, select the correct value to be inserted in each blank [A] through [D] in the following table based on the status report for the 1st month.

Task	Cost Performance Index (CPI)	Schedule Performance Index (SPI)
2D graphics module	0.75	0.667
3D graphics module	A	1.25
Import/export module	1.25	B
User interface module	C	D

Answer group:

    a) 0.741   b) 0.800

    c) 0.833   d) 0.857

    e) 1.000   f) 1.167

    g) 1.200   h) 1.250

    i) 1.286   j) 1.350

Subquestion 3

From the answer group below, select the correct sentence that best describes the project status at the end of the 1st month.

Answer group:

a) The 2D graphics module will be completed beyond the planned date of completion but will not exceed the allocated budget.

b) The 3D graphics module will be completed beyond the planned date of completion but will not exceed the allocated budget.

c) The Import/export module will be completed ahead of the planned date of completion but it will exceed the allocated budget.

d) The User interface module will be completed ahead of the planned date of completion and will not exceed the allocated budget.

Subquestion 4

From the answer group below, select the statements that best describes the most appropriate countermeasure for the project at the end of 1st month.

Answer group:

a) The 2D graphics module task is not progressing as expected. Perform an evaluation in order to determine the root cause and make the necessary adjustments to the schedule and development process.

b) The 3D graphics module task has extra man hours which are not being utilized. Transfer or lend excess man hours to the 2D Graphics module task.

c) The Import/export module is spending more man hours than necessary to complete the task. Advise to reduce man hours by employing a more efficient development method.

d) The User interface module task's progress may indicate a significant mistake in the schedule which could eventually delay the project. Review and adjust the estimates accordingly.

Subquestion 5

Table 5 shows the monthly earned value measurements collected during the first four (4) months of the project.   Assume that the remaining work will be performed at the same cumulative cost performance index (CPI) incurred by the project to date. From the answer group below, select the correct expression to compute the estimated cost of the project at completion.

Table 5: Monthly Earned Value Measurements

Month	Earned Value	Actual Cost
1	207,500	200,000
2	147,500	205,000
3	172,500	220,000
4	125,000	130,000

Answer group:

a) 1,300,000 / (125,000 / 130,000)

b) 1,300,000 / (652,500 / 755,000)

c) 652,500 + 1,300,000 – 755,000

d) 755,000 + 1,300,000 - 652,500