

Markscheme

November 2019

Computer science

Higher level

Paper 2

39 pages

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Subject details: Computer science HL paper 2 markscheme

Mark allocation

Candidates are required to answer **all** questions in **one** Option. Total 65 marks.

General

A markscheme often has more specific points worthy of a mark than the total allows. This is intentional. Do not award more than the maximum marks allowed for that part of a question.

When deciding upon alternative answers by candidates to those given in the markscheme, consider the following points:

- Each statement worth one point has a separate line and the end is signified by means of a semi-colon (;).
- An alternative answer or wording is indicated in the markscheme by a “/”; either wording can be accepted.
- Words in (...) in the markscheme are not necessary to gain the mark.
- If the candidate’s answer has the same meaning or can be clearly interpreted as being the same as that in the markscheme then award the mark.
- Mark positively. Give candidates credit for what they have achieved and for what they have got correct, rather than penalizing them for what they have not achieved or what they have got wrong.
- Remember that many candidates are writing in a second language; be forgiving of minor linguistic slips. In this subject effective communication is more important than grammatical accuracy.
- Occasionally, a part of a question may require a calculation whose answer is required for subsequent parts. If an error is made in the first part then it should be penalized. However, if the incorrect answer is used correctly in subsequent parts then **follow through** marks should be awarded. Indicate this with “**FT**”.

General guidance

Issue	Guidance
Answering more than the quantity of responses prescribed in the questions	<ul style="list-style-type: none"> • In the case of an “identify” question, read all answers and mark positively up to the maximum marks. Disregard incorrect answers. • In the case of a “describe” question, which asks for a certain number of facts <i>eg</i> “describe two kinds”, mark the first two correct answers. This could include two descriptions, one description and one identification, or two identifications. • In the case of an “explain” question, which asks for a specified number of explanations <i>eg</i> “explain two reasons ...”, mark the first two correct answers. This could include two full explanations, one explanation, one partial explanation <i>etc.</i>

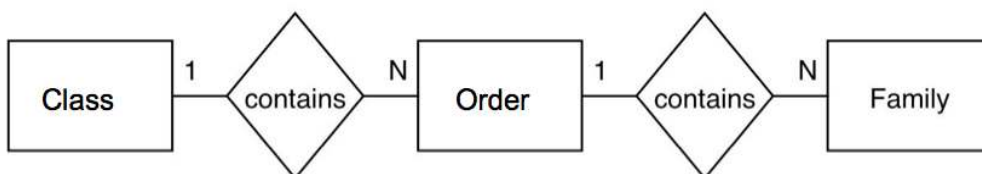
Option A — Databases

1. (a) *Award [1 max].*
 atomicity;
 sorting; [1]
- (b) *Award [2 max].*
 Not all of this information may be necessary for the purposes it is being collected for / asks for too much information;
 Teachers may be concerned about issues of privacy;
 If the information is shared with third parties it could be used / aggregated to identify the teacher / identity theft;
 Teachers may be put off either by the excessive time required to complete the form;
 This may lead to some teachers refusing to complete the application form / not as many teachers will sign up; [2]
- (c) *Award [2 max].*
 Atomicity in transactions ensure that the indivisible series of database operations either all occur, or nothing occurs;
 This prevents updates to the database occurring only partially / this maintains data integrity / consistency; [2]
- (d) *Award [3 max].*
 Isolation specifies the sequence that changes is processed / specifies that any parallel processing must produce the same result as if the processes were carried out sequentially;
 Each post to the thread takes place independently of others;
 One post will be completed before another starts / a post will not become visible until completed;
 Data and the transaction (row for the thread) is locked for that moment when the transaction is carried out;
 The addition of one post to the thread must not displace another's, regardless of the order in which they finally appear;
 A transaction log is created prior to the transaction to allow rollback;
 This means that should an error occur part of the way through the transaction it will be rolled back and the database will return to its original state; [3]

- (e) **Award [2 max].**
Data configuring / applying patches or upgrades;
Setting permissions / passwords / access rights / ensuring security;
Back up / recovery / archiving;
Data cleansing / consistency checks on data / remove data errors; **[2]**
- (f) **Award [4 max].**
The large number of educators is critical to the number of fields included in any composite key;
The composite key must be unique;
Composite key could be made up of several fields;
Allow suitable example (eg combinations of first name, last name, email, phone number etc.);
Allow example that would not be suitable;
Part of the primary key could include a random element in case of duplicated name and dates of birth;
This would require an understanding of the nature of the educators, for example, are they of a particular age which would reduce the possible number of dates of birth, are they from one particular country so certain names would be more likely to occur;
This would influence the number of fields that would be required to reduce the possibility of a duplicate entry occurring; **[4]**

2. (a) **Award [2 max].**
Award [1] for each correct relationship with labels.
Award [1] for a top-down diagram showing the relationships.

One CLASS contains many ORDER;
 One ORDER contains many FAMILY;



[2]

- (b) (i) **Award [2 max].**
 Length check;
 Could ensure only a value within an acceptable range is entered (allow example);
 Type/format check on bill;
 Only numerical (int/float etc);

[2]

- (ii) **Award [2 max].**
 Double entry;
 Will only allow data entry if both match;
 Proof reading;
 Will give a visual check that the data is correct;

[2]

- (c) **Award [2 max].**
 When the length of the bill / beak of the spoonbill is measured it is simply a decontextualized figure such as 10 cm;
 When it is included in the database and interrogated it will have a meaning, so it then becomes information;

The database will contain only the figure “10”;
 the “cm” will not be included and is part of the meaning of the attribute/field.

Note: the “information” mark must reference the database in some way [2]

- (d) **Award [2 max].**
 A high-level / overall / general view of the database;
 Shows the main concepts;
 Shows the main relationships,
 Can be described by a Data Structure Diagram;

[2]

(e) **Award [3 max].**

Data modelling gives a visual representation of the proposed system;
So that all stakeholders have the same understanding of the system;
Shows basic relationships / establishes naming conventions etc;
Some that developers are able to develop the actual database;
Avoiding issues such as redundancy/lack of integrity/lack of consistency;

The data model will take the information from the conceptual schema and logical schema to inform the physical model for the development of the database;
A lack of modelling may result in a structurally deficient implementation with poor data integrity / redundant data;
This may mean developing prototypes of the database to test whether the proposed structure of the database will function as intended;

[3]

(f) **Award [3 max].**

Note: only award full marks if there is a valid reference to the scenario.

Referential integrity requires that a value used as a foreign key corresponds to a value of a primary key / validates the database through relationships;
Therefore if the Ciconiiformes/order of the Spoonbill is not in the database, you will not be able to add it because of referential integrity;
Referential integrity constraints;
Ensure that if a record is updated or deleted, these changes will be made in related cells and the possibility of update anomalies is reduced / eliminated;

[3]

3. (a) **Award [2 max].**
Note: Allow answers that refer to any stage of normalisation.
Each data item hasn't be broken down any further / contains repeating data;
Each row is not unique / does not contain a primary key;
Each field/column does not have a unique name / does not have atomic values; **[2]**
- (b) **Award [2 max].**
This would mean that data is duplicated within a table / allow an example of duplicated data in this table;
However, when it is updated, it may not be updated in all cases;
Which could lead to anomalies within the data and the incorrect information being used; **[2]**
- (c) **Award [4 max].**
Award [1] for all relevant tables selected (Lorry and Trailer);
Award [1] for all relevant fields selected (Driver and Tel);
Award [1] for correct condition;
Award [1] for correct link between tables;
- ```
SELECT Driver, Tel
FROM Lorry INNER JOIN Trailer
ON Trailer.TrailerID = Lorry.TrailerID
WHERE TRAILERSPACE > 60;
```
- Accept logically equivalent answers written in English or a Data Manipulation Language.* **[4]**



(d) *Award [7 max].*

*Award marks as follows:*

Separate, correct DRIVER table;

FK links Driver to TRUCK table (driver always drives same truck);

New "journey" table created – called JOURNEY in examples below;

JOURNEY PK either a new JourneyID field, or a composite key as shown below;

Correct FK links to TRUCK and TRAILER tables in JOURNEY table;

Coupled.to and Coupled\_from in correct table;

TRAILER table + PK correct;

DRIVER (Driver, Tel)

TRUCK (TruckID, Truckmake, Energysource, Driver)

JOURNEY (TruckID, TrailerID, Coupled\_from, Coupled\_to)

TRAILER (TrailerID, Trailerspace)

DRIVER (Driver, Tel)

TRUCK (TruckID, Truckmake, Energysource, Driver)

JOURNEY Journey ID, TruckID, TrailerID, Coupled\_from, Coupled\_to)

TRAILER (TrailerID, Trailerspace)

[7]

4. (a) **Award [4 max].**  
Standards and support are available for RDB...  
...make it more stable / easier to resolve issues / easier to recruit staff;  
  
More user tools exist for RDBs...  
...such as report generators / mail merge / security level permissions / concurrent access.  
  
Easier to visualise data and relationships...  
...so more likely to have a correctly modelled database i.e. has no redundancy / improved integrity  
  
RDB tables and relationships are simple to implement...  
...an OODB requires an understanding of concepts of OOP;
- Mark as [2] and [2].* **[4]**
- (b) **Award [2 max].**  
Repository data stored are historical/time variant;  
Data is collected from different sources;  
OLAP systems for reporting and data analysis (eg data mining) / provides businesses with information for informed decisions;  
Provides tools so that data can be validated, reformatted, reorganized, summarized, and restructured;  
Optimised for data retrieval; **[2]**
- (c) **Award [2 max].**  
*Data is from my different external sources and (therefore) in many different formats;*  
*For example, dates may be dd/mm/yy or mm/dd/yy or yy/mm/dd (allow any valid example);*  
*To allow meaningful analysis, it must be in the same format/standardised;* **[2]**
- (d) **Award [2 max].**  
*Notes: maximum marks only if reference is made to the scenario*  
*Do not award marks just for a description of time-stamping*  
  
The usefulness of information is often time dependent;  
*Example relating to the US presidential election, such as*  
Electoral opinions before a public debate may have less value than those after the debate; **[2]**

(e) **Award [2 max].**

*Notes: don't accept the word "link" on its own as a descriptor.  
maximum marks only if reference is made to the scenario.*

They use link analysis in order to establish relationships / associations between different data sets / different entities in the same data set;

*Examples relating to the US presidential election, such as:*

How people voted in relation to some other factor, e.g. the level of use of social media / where they took their vacations / size of family ...;

**[2]**

(f) **Award [2 max].**

*Note: maximum marks only if reference is made to the scenario*

They look for any unusual activity (anomaly pattern) in transactions;

*Examples relating to the US presidential election, such as*

Unusual switch in pre-electoral voting opinions;

Sudden pro-candidate or anti-candidate sentiment in a particular state;

**[2]**

(g) *Award [6 max].*

Mark as follows:

Award [1] for a generic advantage of data mining;

Award [1] for expanding on this advantage;

Award [1] for linking this to the scenario;

Similarly for a disadvantage;

Award [1] for a valid conclusion;

*Advantages of data mining [3 max].*

Clustering / cluster analysis allows objects to be treated as one group enabling the uncovering of previously hidden patterns;

For example, cluster analysis may search groups by race or gender to discover if a candidate is unpopular with a demographic;

Classification methods (e.g. genetic, rough set, fuzzy set) can be used to recognize patterns that describe the groups to which an item belongs;

For example, classifying voters by income may provide useful information that can affect future publicity strategies;

Association analysis allows a series of statistical relationships to be further explored or tested;

Associations look for If-then rules that predict a particular stance on a controversial topic (eg abortion) may influence the religious voters;

*Disadvantages of data mining [3 max].*

Data mining is based on the data collected from individuals;

This data may be sensitive personal information that the individual concerned may not want to be shared;

This personal data may be reaggregated to compromise the privacy and/or anonymity of the data subjects;

*Conclusions [1 max].*

The development of more sophisticated processing algorithms is inevitable, so although there are potential concerns about the invasive nature of data mining, providing sufficient safeguards are put in place, there is nothing inherently wrong with this;

Data mining is the start of the slippery slope of the state or multinational companies holding inappropriate quantities of personal data about citizens that is of limited value. Therefore, unless the privacy and/or anonymity of the data subjects can be guaranteed, this is an unethical practice;

[6]

**Option B – Modelling and simulation**

5. (a) *Award [2 max].*  
 36300;  
 if interest only award [1 mark max], \$6300; [2]

(b) *Award [5 max].*  
*Award [1] Initial investment 30000 for month 0;*  
*Award [1] Investment 1000 each month;*  
*Award [1] Interest rate of 0.005 \* Principal*  
*Award [1] Calculate compound interest for 12 months;*  
*Award [1] Add interest to the investment;* [5]

|           | <b>A</b> | <b>B</b>                | <b>C</b>           | <b>D</b>              | <b>E</b>              |
|-----------|----------|-------------------------|--------------------|-----------------------|-----------------------|
| <b>1</b>  | Month    | Total at start of month | Interest for month | Addition to principal | Total at end of month |
| <b>2</b>  | 1        | 30000                   | =B2*0.005          | 1000                  | =B2+C2+D2             |
| <b>3</b>  | 2        | =E2                     | =B3*0.005          | 1000                  | =B3+C3+D3             |
| <b>4</b>  | 3        | =E3                     | =B4*0.005          | 1000                  | =B4+C4+D4             |
| <b>5</b>  | 4        | =E4                     | =B5*0.005          | 1000                  | =B5+C5+D5             |
| <b>6</b>  | 5        | =E5                     | =B6*0.005          | 1000                  | =B6+C6+D6             |
| <b>7</b>  | 6        | =E6                     | =B7*0.005          | 1000                  | =B7+C7+D7             |
| <b>8</b>  | 7        | =E7                     | =B8*0.005          | 1000                  | =B8+C8+D8             |
| <b>9</b>  | 8        | =E8                     | =B9*0.005          | 1000                  | =B9+C9+D9             |
| <b>10</b> | 9        | =E9                     | =B10*0.005         | 1000                  | =B10+C10+D10          |
| <b>11</b> | 10       | =E10                    | =B11*0.005         | 1000                  | =B11+C11+D11          |
| <b>12</b> | 11       | =E11                    | =B12*0.005         | 1000                  | =B12+C12+D12          |
| <b>13</b> | 12       | =E12                    | =B13*0.005         | 1000                  | =B13+C13+D13          |

- (c) *Award [6 max].*  
**An array does not need to be used to obtain full marks.**

*Award [1] Create array or variables / initialise array or variables /  $P[0] = 30\,000$ ;*

*Award [1] Create interest rate and assign it to 1.005;*

*Award [1] Calculate interest;*

*Award [1] Add interest and 1000 to each month;*

*Award [1] If statement to determine the correct tax rate;*

*Award [1] Output investment - tax;*

```

P[0:12] = 0
P[0] = 30000
RATE = 1 + 0.005
TAX = 0
Loop X from 0 to 11
 INVESTMENT = P[X] * RATE
 P[X+1] = 1000 + INVESTMENT
 PROFIT = INVESTMENT - P[X]
 If P[X+1] < 40000 then
 TAX = TAX + (PROFIT * 0.25)
 Else
 TAX = TAX + (PROFIT * 0.40)
 End if
End Loop
Output ("Investment Value: ", P[12] - TAX)

```

*Alternative solution without an array*

```

PRINCIPAL = 30000
RATE = 1 + 0.005
TAX = 0
Loop X from 0 to 11
 OLD_PRINCIPAL = PRINCIPAL
 INVESTMENT = OLD_PRINCIPAL * RATE
 PRINCIPAL = 1000 + INVESTMENT
 PROFIT = INVESTMENT - OLD_PRINCIPAL
 if PRINCIPAL <= 40000:
 TAX = TAX + (PROFIT * 0.25)
 else:
 TAX = TAX + (PROFIT * 0.40)
 end if
End Loop
Output ("Investment Value: ", PRINCIPAL - TAX)

```

**[6]**

(d) *Award [4 max].*

A what if scenario can be employed;

A mathematical model will allow you to adjust variables to see what impact that will have on the investment;

You can see exactly what is happening to the money each month;

If the client decides to pay in less or more money for a given month you can see what affect this will have on the profits;

If the interest rate changes, you will be able to see what changes this has on profit;

If the tax rate changes you can see how this affects the investment profits.

**[4]**

6. (a) *Award [1 mark] for reason and [1 mark] for expansion [4 marks max].*

Cost;

Building a distribution centre is expensive so it is impractical to build four centres to see which one is the best location / build the centre in a poor site location;

Time;

The time to build and run the simulation is much less than building a distribution centre;

Amendments to input data / extra variables added;

The simulation could be adjusted to factor in unforeseen variables / run worst case scenario eg roadworks, changes in traffic congestion, new housing being built in the area;

*Mark as [2] and [2].*

**[4]**

(b) (i) *Award [2 max].*

Road networks to and from the distribution sites;

Location of the supermarkets / distance to the supermarkets;

Location of the port / airport / station that delivers the products to the distribution centre;

Cost of the land for each of the sites;

Average labour costs in the area;

Time taken to drive from the site to each supermarket at different times of the day;

**[2]**

(ii) *Award [2 max].*

Overall costs to build the distribution centre for each site;

Running costs to receive shipments / distribute goods;

Time taken to build the distribution centre at each of the sites;

Time taken to distribute goods / shipments to arrive;

**[2]**



(iii) *Award [6 max].*

**Overall costs to build the distribution centre for each site;**

Inputs of labour rate, time taken to build, cost of land are inputted;  
Simulation is run with a variety of scenarios (*eg* number of workers, rate of pay for labour; cost of materials);

**Running costs to receive shipments / distribute goods;**

Inputs of fuel cost, distance to each supermarket / sites, fuel economy, number of trips, *etc*  
Simulation is run with a variety of scenarios (*eg* fuel price increases, congestion reduces fuel economy, more trips needed to ship goods)

**Time taken to build the distribution centre at each of the sites;**

Inputs for number of diggers, number of workers, building materials delivery schedule;  
Simulation is run with scenarios (delay in window deliveries, change in the number of builders, *etc*)

**Time taken to distribute goods / shipments to arrive;**

Inputs for time taken to travel to destination, number of vehicles; length of time to load / unload goods, *etc*;  
Simulation is run with scenarios (*eg* Increased traffic congestion, number of vehicles shipping goods, *etc*)

[6]

(c) *Award [2 max].*

The cost outweighs the benefit;

It may be impossible to simulate a simulation / too many variables / too many confounding factors;

No positive reasons such as time/danger/modification;

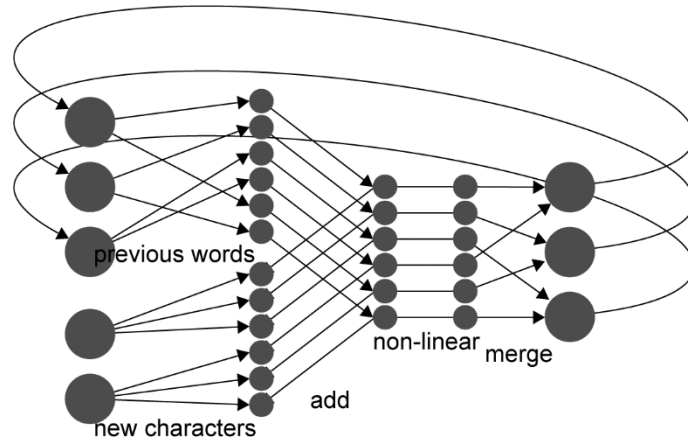
[2]

7. (a) **Award [4 max].**  
Continuously collected data (from satellite, electronic trackers, observation);  
Data on current speed of antelopes / length of time for the entire herd to pass a certain point;  
Previous migration paths stored and used to provide additional data;  
Predicted path calculated to determine when the antelopes will hit the railway line / highway;  
Model may show the expected time of highway / railway inception updated in real time; **[4]**
- (b) **Award [4 max].**  
2D visualization gives a rapid way of seeing what is happening relative to positions on the map and updates quickly;  
A 3D model may have delays updating providing information too late;  
  
The antelope is always on the ground / in a 2D space  
So there is no need to map in 3D space  
  
2D visualization will update rapidly because it is less complex;  
A 3D model that requires more powerful graphics cards (GPU); **[4]**
- (c) **Award [4 max].**  
**Award [2 max] for technical difficulties of collecting data;**  
**Award [2 max] for a reasonable solution to the problem**  
  
Difficult to put people on the ground to keep pace with the antelope;  
Because the area is inhospitable / mountainous;  
The antelope may cross the road at any point over a vast distance so the number of people required is prohibitive;  
Poor visibility may affect visuals of antelopes / too dark for cameras;  
Transmission may get disrupted in a remote place like Tibet;  
So satellite transmissions as a back up system; **[4]**

8. (a) **Award [2 max].**  
Printed text quality may be poor or faint/may use an unusual typeface *eg* BrushScript/In certain typefaces some characters can look similar *eg* sans serif; For example, 5 and S may be confused/Numbers may be confused with letters 1 or I; [2]
- (b) **Award [2 max].**  
ANN can be trained to recognise handwriting styles / supervised learning;  
ANN can learn to apply existing knowledge to new handwriting styles / unsupervised learning;  
ANN can recognize parts of the image to determine if it is a match / doesn't require the entire image to be a match; [2]
- (c) **Award [4 max].**  
The ANN accesses a database of correctly stored characters;  
ANN breaks the image into smaller parts / applies a filter (2 or 3 pixels) to a section of the image;  
Calculate whether the pixels match / multiple each image pixel to the feature pixel, add them up, divide by number of pixels / perfect match will be 1;  
Apply convolution / repeat the application of the filter over and over;  
Apply a ReLU (Rectified Linear Units) layer (remove negative values) to reduce the mathematical calculations;  
Apply pooling to shrink the image stack;  
Use the stack of filter images / convolution layer to see if the image is a match; [4]
- (d) **Award [2 max].**  
Dictionary of words;  
Predictive text algorithms;  
The ability to recall the previous words in the sentence / memory;  
An understanding of language structure *eg* nouns, verbs, adverbs, *etc*;  
Previous words must be added back into the neural network; [2]

- (e) **Award [6 max].**  
If they have used a diagram should include:  
**Award [1]** Input for previous words;  
**Award [1]** Input for new characters the user enters;  
**Award [1]** Hidden layers;  
**Award [1]** Weights inputted into the network;  
**Award [1]** Combining the two inputs;  
**Award [1]** Non-linear regression / sigmoid function;  
**Award [1]** Merge layers to produce output;  
**Award [1]** Back propagation / Output that re-enters the ANN;

[6]



- (f) **Award [4 max].**  
Unsupervised learning may have a poor set of words / text-speak is used;  
So the ANN database doesn't contain text-speak words so doesn't learn;

Vanishing gradient problem / Exploding gradient problem;  
Gradient signal is multiplied many times by weight matrix / The gradient signal can become smaller at every training step (vanishing) / can become excessively large at every training step (exploding) / This can make learning very slow or stops it completely;

[4]

**Option C – Web science**

9. (a) (i) *Award [1 max].*  
Hypertext transfer protocol secure/https;  
*Do not accept http.* [1]
- (ii) *Award [4 max].*  
To allow successful communication to take place;  
Ensure data integrity such as error checking;  
Regulate flow control such as prevent a fast sender from overwhelming a slow receiver;  
Managing deadlock when two processes are each waiting for the other to complete before proceeding;  
Manage congestion;  
Manage error correction such as enabling reliable delivery of digital data over unreliable communication channels;  
Manage packet switching;  
Manage security / encryption / authentication .....; [4]
- (b) (i) *Award [1 max].*  
Server-side scripting; [1]
- (ii) *Award [1 max].*  
filter\_var(\$\_POST['email'], FILTER\_VALIDATE\_EMAIL);  
mail(\$to, \$subject, \$body, \$headers, "-f " . \$from); [1]
- (iii) *Award [3 max].*  
The script reads the email id;  
Checks if the email address entered is valid/executes the **filter( ) function**;  
If correct, then the **mail( ) function** of PHP adds the email address and displays that your email address has been added to our mailing list;  
Else, the error message will be displayed;  
There is no error message if the email address is invalid.
- OR**
- The script gets an e-mail address via POST
  - It checks whether it is valid via a filter function; if not, it does nothing
  - If it is valid, it checks with the mail function, and displays either a success or an error message [3]
- (c) *Award [1 max].*  
Social Networking/Facebook/Social Media/Twitter;  
Forums;  
Online chat; [1]

(d) *Award [5 max].*

***Advantages [2 max]***

The use of black hat SEO techniques may increase the visibility of the OrderYourFoods website;  
Which will bring a short term gain;

***Disadvantages [2 max]***

Black hat techniques are unethical;  
Use of these techniques may lead to blacklisting;

***Evaluative comment [1 max]***

*OrderYourFoods* may decide that the need to increase their visibility, and increase their sales potential, so this may be a pragmatic (if unethical) compromise;

*OrderYourFoods* may decide that the potential long term risks that may arise from the use of an unethical technique may not be a risk that is worth taking / may affect the company's reputation;

**[5]**

10. (a) **Award [1 max].**  
Software that interrogates a database of web pages; [1]
- (b) **Award [4 max].**  
**PageRank algorithm [2 max]**  
PageRank works by counting the number and quality of inlinks of a page to determine a rough estimate of how important the website is;  
The assumption is that more important websites are likely to receive more links from other websites;  
Pages are given a score (rank) / counts links per pages;
- HITS algorithm [2 max]**  
Based on authorities and hubs;  
Authorities: A page is called an authority, if it contains valuable information and if it is truly relevant for the search query. It is assumed that such a page has a high number of in-links;  
Hubs: These are pages that are relevant for finding authorities. They contain useful links towards them. It is therefore assumed that these pages have a high number of out-links; [4]
- (c) **Award [3 max].**  
**Local client-server architecture [1 max]**  
The server is the central communicator between clients (eg email/chat server)/allows different clients to access and manipulate data;
- Cloud computing [1 max]**  
Cloud computing puts the focus on sharing computing resources over the internet;
- Differences between the two [1 max]**  
Cloud computing is often offered as a service to individuals and companies whereas local client server architecture is based at an organizational level;  
Cloud computing can scale up or down depending on current demands more easily than local client server networks;  
Client / server networks are more secure than the cloud as the data transmission is carried out locally;  
Client / server networks have lower levels of latency than the cloud as the data transmission is carried out locally; [3]

- (d) (i) **Award [1 max].**  
Lossless (Compression); **[1]**
- (ii) **Award [4 max].**  
**Advantages of using compression [2 max]**  
Allows for more rapid upload/download as the compressed file is smaller than the original;  
Scrolling through the coursework may be quicker;
- Disadvantages of using compression [2 max]**  
This may mean that the overall quality of the work is reduced;  
This may be an issue when printing the work / or the quality of the image is a key contributor to the overall quality of the work;
- Overall comment [1 max]**  
The impact of using compression may be dependant on the context in which the work is compressed; **[4]**
- (e) **Award [2 max].**  
Interoperability means a computer program can communicate and exchange information across a range of platforms;  
Open standards are publically and free standards that enable interoperability; **[2]**



11. (a) *Award [3 max].*  
The Internet is growing exponentially meaning that more and more nodes (in this case IB World Schools) can be added;  
This has led to greater connectivity between the different nodes;  
However, the number of hops required to transmit information from one node to another is growing linearly;  
Therefore, each node can access the increased number of nodes with no discernible latency which makes increased levels of collaboration between these nodes possible and desirable; [3]
- (b) *Award [3 max].*  
Browser Retrieves a Web Page;  
The web browser retrieves (or fetches) code, usually written in HTML (HyperText Markup Language) and other computer languages, from a web server;  
Then, it interprets this code and displays it as a web page for you to view;  
  
Browser acts as a bridge between URL and DNS;  
The user inputs the URL / website domain name on web browser's address bar;  
The web browser passes this website domain name to a domain name server; [3]
- (c) *Award [3 max].*  
User type the domain name into the URL search area on the web browser and press "Enter" on the keyboard.  
  
The domain name is intercepted by a "Domain Name Server" or DNS.  
  
The main function of the DNS is to look up in its database the domain name you have typed and find the matching IP address.  
  
It then forwards the request onwards, using this address.  
  
If it cannot find the IP address in its own database, it then contacts other Domain Name Servers until it finds it, or if it can't find it anywhere, it displays a "web site not found" message to you.  
  
When the request reaches the destination, the pages are sent back. [3]

(d) *Award [5 max].*

***Copyright issues [3 max]***

Copyright issues may occur because of the ease of access to materials on the World Wide Web;

When material is accessed on the World Wide Web it may breach copyright rules in a number of ways (such as copying / publishing/ public display), often without the user realizing they have done so;

It may also be a potential issue if the user is not aware of the complicated and extensive copyright laws;

The continuing technical evolution of the web may mean that new practices emerge that may inadvertently breach existing copyright laws;

***IP [3 max]***

Potential IP issues may occur with web sites for a number of reasons such as being linked to copyright, trademarks, patents;

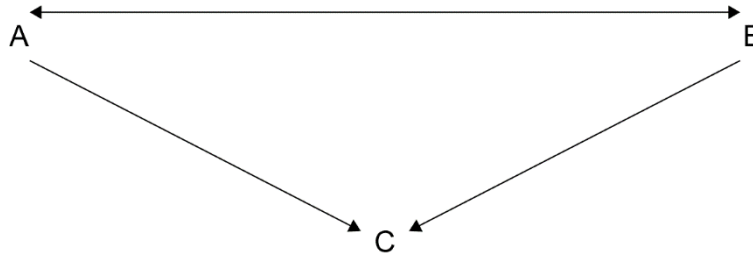
When material is downloaded it may breach IP rights;

When material is modified without author's permission;

These IP rights may vary between countries which leads to some acts being an IP issue in one country, but not in another;

[5]

12. (a) **Award [2 max].**  
*Award [1] for bi-directional arrow between A & B.*  
*Award [1] for uni-directional arrow between A & C as well as B & C.*



[2]

- (b) **Award [3 max].**  
Connectivity is a basic concept in Graph Theory. Graph theory can be used to model or analyse the nature of the connectivity on a selected area, the web;  
In World Wide Web, each web page is represented by vertex/node;  
The hyper links between web pages are represented by edges/lines in the graph;  
Arrows would indicate the direction of the hyperlinks (1-way / 2-way);  
In Graph Theory, a graph is said to be connected if there is a path between every pair of vertex. From every vertex to any other vertex, there should be some path to traverse. That is called the connectivity of a graph;  
Similar concept is used in connectivity of World Wide Web, where each vertex representing a type of web page is connected to any other vertex representing other kind of web pages;

[3]

- (c) **Award [4 max].**  
Multimedia are assigned meta-tags;  
If the appropriate tag is not assigned, the media will not appear in the search;

Searched by image similarity;  
Google search the web using the image inputted by the user;

Non-text based searches are more difficult;  
Because there a no specific content to search for;

Fewer search engines support multimedia searches;  
Therefore the search engine may not be as efficient;

*Mark as [2] and [2].*

[4]

(d) *Award [5 max].*

***Advantages of using collective intelligence [2 max]***

Collective intelligence costs significantly less per unit / pro rata than hiring a professional;

A single task is being worked on simultaneously by numerous individuals so it can be completed much more rapidly than using a single person;

It allows access (maybe part time or at very short notice) to a large number of contributors for specific events or tasks;

***Disadvantages of using collective intelligence [2 max]***

It may be hard to ensure sufficient quality control occurs as collective intelligence is a very deregulated environment;

It may be hard to verify the originality of the work, or which work was originally completed by who;

There may be many ideas, but it may be difficult evaluate each idea thoroughly as there may be a lack of centralised planning and/or a lack of a clearly defined hierarchy;

***Conclusions [1 max]***

Collective intelligence can help organizations in solving a problem in certain contexts;

These may include where there is a need to provide information quickly such as a health related requirement, or where the final information is not critical to the wellbeing of others, for example a site such as Wikipedia;

[5]

**13. Award [6 max].**

The journey from the care home to the local shops may lead to Pepper encountering a large range of environments that may go beyond the ambient intelligence that Pepper possesses;

Which may mean that the information that Pepper can obtain from the environment by using ambient intelligence may be limited and lead to sub-optimal decisions being taken, some of which could have serious consequences;

Some of the residents may have trust issues associated with relying on Pepper, or they have be too trusting and delegate all decision making to Pepper when it is not appropriate;

Families and carers for these residents may have concerns about what information is being collected and shared by Pepper;

There may be issues of accountability that have not been resolved should an accident occur when Pepper is acting as a decision maker;

There may be technical issues such as black spots where Pepper is unable to communicate with the IoT that need to be addressed;

The trialing of Pepper may not have been sufficiently rigorous to train Pepper to act “correctly” in any given situation;

**[6]**

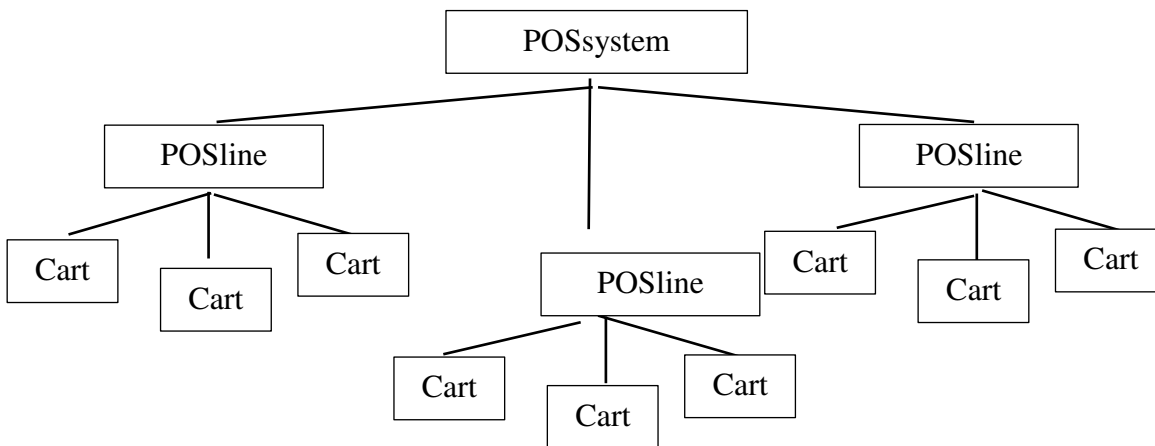
**Option D – Object-oriented programming**

14. (a) **Award [1 max].**  
 Aggregation;  
 POSsystem has a (many) POSline(s);  
 Allow 1 to many;

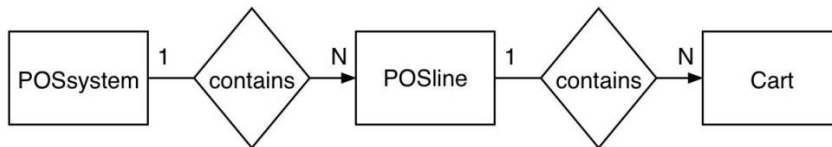
[1]

- (b) **Award [2 max].**  
 Award [1] for one POSsystem connecting to multiple POSlines;  
 Award [1] for one POSline connecting to multiple Carts;

Example answer:



Alternative answer:



Allow diagram showing aggregation for both (diamond at POSsystem end or 1 to many)

[2]

- (c) **Award [1 max].**  
 The (unique) name of a program element (variable / method / class);  
 Must have "name" or equivalent.

[1]

- (d) **Award [3 max], [1 mark each] for definitions of a class and an object and [1 mark] for an example relating to the UML diagram that involves both class and object for either the POSline or the Cart classes.**

The class is the blueprint / template of an object / defines the actions and properties of an object / an abstract representation of an object;  
 An instantiation is the (creation of an) actual object / example of an object / object filled with data / assigned space in memory;

The class `POSline` stores instantiated objects of the `Cart` class;  
 The class `POSline` uses the constructor to set the (object's) variables;  
 An instance of `POSline` has values for `id`, `active` and `line`;  
 Allow similar example for the `Cart` object;

[3]

- (e) **Award [2 max].**  
**Award [1] for using `new`;**  
**Award [1] for `Cart[20]`;**  
 Allow with or without `private`.

```
private Cart[] line = new Cart[20];
```

- (f) **Award [3 max].**

**Award [1] for correct loop construction (for a while loop this includes initialization and incrementation);**  
**Award [1] for correct condition (can be within the loop construct);**  
**Award [1] for correct assignment;**

```
public void joinLine(Cart newCart){
 int i=0;
 while (this.line[i] != null) {i++;}
 this.line[i] = newCart;
}
```

**[3]**

**Notes: Do not penalize the absence of the keyword “this” in any question.**  
**With for loops, allow variations of `line.length()` – mark the logic**

**Further examples:**

**Note: if the answer takes size of array into account then the given condition must be correct.**

```
public void joinLine(Cart newCart)
{
 int i=0;
 boolean placed = false;
 while (i<20 && placed = false)
 {
 if this.line[i]= null;
 {
 this.line[i] = newCart;
 placed = true;
 }
 i = i+1;
 }
}
```

```
public void joinLine(Cart newCart)
{
 for (int i; i<20; i++)
 {
 if (this.line[i] == null)
 {
 this.line[i] = newCart;
 break;
 }
 }
}
```

(g) **Award [4 max].**

**Award [1]** for declaring, initialising and returning a `Cart` variable;  
**Award [1]** for correct loop (including initialisation and incrementation);  
**Award [1]** for assigning / shifting;  
**Award [1]** for assigning `line[19]` to null;

```
public Cart leaveLine(int n){ // given in the stem
 Cart result = this.line[n];
 for (int i=n; i<19; i++){
 this.line[i] = this.line[i+1];
 }
 this.line[19] = null;
 return result;
}
```

**[4]**

15. (a) **Award [2 max].**

A new class is derived from an existing class;  
 The new class inherits all variables/data/properties and methods/behaviours of the other class;  
 The derived class is called a subclass/child, and the original is called a superclass/parent;

**[2]**

(b) **Award [3 max].**

**Award [1]** for an advantage;  
**Award [1]** for some elaboration;  
**Award [1]** for a reference to the context;

Note: to a certain extent mixing and matching can take place

It promotes code reuse;  
 because the superclass `POSline`;  
 holds common data and actions that are shared by all newly developed classes;

It reduces maintenance overhead;  
 because you only have to update the superclass;  
 in this case `POSline`;

allows extensibility / ability to create other classes easily;  
 specific types of check-out can be created;  
 reducing development time / costs / testing;

**[3]**

(c) **Award [4 max].**

Saves development time;  
 Since classes and their methods do not need to be rewritten;

Promotes abstraction;  
 Because reusable code exists that functions without knowledge of internal working;

Libraries contain error-free / robust code;  
 because it has been used and tested many times;

Promotes efficiency / organization;  
 As code will be shorter / easier to read / develop;



Familiarity with libraries;  
Allow for easier maintenance / modification;

*Mark as [2] and [2].*

[4]

(d) *Award [2 max].*

POSline, which consists of the check-out and the line, needs to be changed;  
so that the check-out and the line of carts are now separated / could be two  
different classes;  
new line class could contain an array of check-out objects;  
or, if only 1 line, the main class could assign individual carts to one of an array of  
check-outs;

[2]

(e) *Award [4 max]. Mark as 4 separate points.*

Teams may be located in different countries;  
therefore have communication issues;  
due to different languages;  
or different time zones;  
inability to discuss face-to-face;  
Problems with different conventions (e.g. date format);  
Managing the teams in different locations may be problematic (allow example);  
Teams may not collaborate well due to personality issues;  
Development time might increase;  
Due to time lags between communications;

[4]

16. (a) *Award [2 max].*

`active` indicates that a POS counter is either open (true) or closed (false);  
`boolean` uses the least memory space / one bit to represent this data;

[2]

(b) *Award [8 max].*

*Award [1] for a correct method header;*  
*Award [1] for correctly declaring and returning a new `POSline` variable;*  
*Award [1] for attempting to use modulo division / declaring and initialising a flag;*  
*Award [1] for a loop with one correct terminal condition, including increment of `i`;*  
*Award [1] for the second correct loop condition;*  
*Award [1] for correctly checking that `i` is odd / checking and setting the flag;*  
*Award [1] for copying a cart from the original line;*  
*Award [1] for correctly adding every second cart to the new line;*  
*Award [1] for a reasonable attempt at removing every second cart;*  
*Award [1] for correctly removing every second cart from the original line;*

```
public POSline split(POSline oldLine){
 POSline newLine = new POSline();
 Cart temp; // optional, see below
 int i=0;
 boolean remove=false;
 while((i<20)&&(oldLine.getLine(i)!=null)){
 if (remove) {
 temp = oldLine.getLine(i); // can be combined
 newLine.joinLine(temp);
 }
 remove = !remove;
 i++;
 }
 remove=false;
 while((i<20)&&(oldLine.getLine(i)!=null)){
 if (remove) {
 temp = oldLine.leaveLine(i); // shifts carts
 remove = !remove;
 }
 else{
 i++;
 }
 }
 return newLine;
}
```

*Example answer using modulo division (MOD):*

```
public POSline split(POSline oldLine){
 POSline newLine = new POSline();
 int i=0;
 while((i<20)&&(oldLine.getLine(i)!=null)){
 if (i%2==1) {
 newLine.joinLine(oldLine.getLine(i)); //combined
 }
 i++;
 }
 while(i>0){ // must be reverse order
 if (i%2==1) {
 temp = oldLine.leaveLine(i);
 }
 i--;
 }
 return newLine;
}
```

*Example answer using a flag that combines both copy and remove actions (not anticipated):*

```
public POSline split(POSline oldLine){
 POSline newLine = new POSline();
 int i=0;
 boolean flag=false;
 while((i<20)&&(oldLine.getLine(i)!=null)){
 if (flag) {
 newLine.joinLine(oldLine.leaveLine(i));
 }
 else i++;
 flag = !flag;
 }
 return newLine;
}
```

[8]

(c) *Award [4 max].*

(Any) software can be considered as a form of Intellectual property;  
Company should consider whether there is a need to acknowledge the work of other programmers (don't accept answers talking about plagiarism);

Open source software may have undergone many changes from the original;  
So adequate testing of the final product must take place;  
to prevent any malfunction that will affect their customers;

The company will be promoting the spread of open source software;  
Helping to break the monopolies of the major IT companies;  
To the benefit of people / countries with reduced financial resources;

The use of open-source software means that the code can (more easily) be read/understood/ hacked by others;  
Leading to possible data breaches for their customers;

Code may contain malware;  
Leading to possible data breaches for their customers;

Using open-source software results in less work for programmers;  
This affecting their livelihood;

*Mark as [2] and [2].*

Notes:

- *Award 2 marks for a valid issue if a detailed discussion has been provided*
- *Only give credit for issues that have some ethical connection*

**[4]**

17. (a) *Award [2 max].*  
 A pointer to a memory location;  
 where the object is stored; [2]

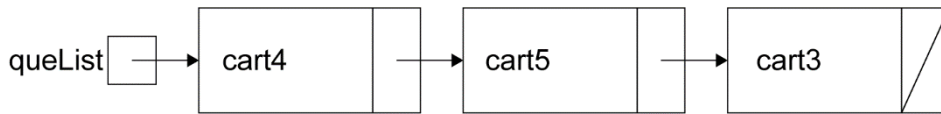
(b) *Award [4 max].*  
*Award [1] for declaring a result variable (or similar)*  
*Award [1] for correct use of .getCart()*  
*Award [1] for reassigning the head of the list*  
*Award [1] for returning the correct result (either the Cart or null)*

```
public Cart removeFirst()
{
 Cart result = null;

 if (head != null)
 {
 result = head.getCart();
 head = head.getNext();
 }
 return result;
}
```

[4]

(c) *Award [2 max].*  
*Award [1] for a three nodes in order.*  
*Award [1] root pointer (with or without identifier) **and** null pointer.*



[2]

(d) *Award [2 max].*  
 The abstract data structure queue is a FIFO structure / only allows addition at the end and removal from the front;  
 this is not sufficient because customers can change lines at any time;

Has no fixed length;  
 Which could lead to unmanageable/very long queues;

*Note: do not award marks for responses that focus on dynamic vs static, since queues can be implemented either way.*

[2]

- (e) **Award [6 max].**  
**Award [1]** for declaring all variables used (including loop variable *i*);  
**Award [1]** for initialising variable(s) for list traversal;  
**Award [1]** for dealing separately with the case where *n* equals 1;  
**Award [1]** for attempted looping through the linked list until the correct position;  
**Award [1]** for correct loop using `curr = curr.getNext()`; (or similar)  
**Award [1]** for correctly rearranging references to unhook the *n*th node;  
**Award [1]** for returning the correct result;

*Example answer using two CartNode variables:*

```
public Cart leaveList(int n){
 Cart result = null; // explicit default result
 CartNode prev = null;
 CartNode curr = head;

 if (n==1){
 result = removeFirst();
 }
 else{
 int i=1;
 while (i<n){ // no need to check for null
 prev = curr;
 curr = curr.getNext();
 i++;
 }
 result = curr.getCart();
 prev.setNext(curr.getNext());
 }
 return result;
}
```

*Example answer using one CartNode variable:*

```
public Cart leaveList(int n){
 Cart result = null;
 CartNode curr = head;

 if (n==1){
 result = removeFirst();
 }
 else{
 int i=1;
 while (i<n-1){ // no need to check for null
 curr = curr.getNext();
 i++;
 } // curr points to node (n-1)
 result = curr.getNext().getCart();
 curr.setNext(curr.getNext().getNext());
 }
 return result;
}
```

**[6]**

(f) *Award [2 max] for including any of the following elements on the discussion*

Indentation / Use of white space  
Annotations  
Meaningful identifiers  
Capitalization conventions

*Award [2 max] for including any of the following reasons in the discussion*

Helps understanding / reading;  
For easier maintenance / extension;  
For better team-work / collaboration / development;  
To help with de-bugging;

*Mark as [2] and [2].*

**[4]**