



# Markscheme

May 2019

Computer science

Standard level

Paper 2

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**Subject details: Computer science SL paper 2 markscheme**

### Mark allocation

Candidates are required to answer **all** questions in **one** Option. Total 45 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:

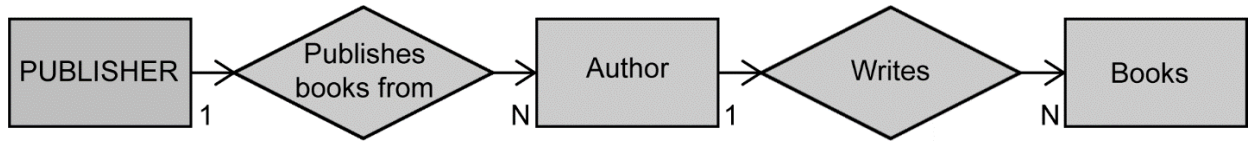
- Each statement worth one point has a separate line and the end is signified by means of a semi-colon (;).
- An alternative answer or wording is indicated in the markscheme by a “/”; either wording can be accepted.
- Words in ( ... ) in the markscheme are not necessary to gain the mark.
- If the candidate’s 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"> <li>• In the case of an “identify” question, read all answers and mark positively up to the maximum marks. Disregard incorrect answers.</li> <li>• In the case of a “describe” question, which asks for a certain number of facts eg “describe two kinds”, mark the first two correct answers. This could include two descriptions, one description and one identification, or two identifications.</li> <li>• In the case of an “explain” question, which asks for a specified number of explanations eg “explain two reasons ...”, mark the first two correct answers. This could include two full explanations, one explanation, one partial explanation <i>etc.</i></li> </ul>

## Option A — Databases

1. (a)



Award [2 max].

Award [1] for correct relationship "publishes books from".

Award [1] for correct relationship "writes".

[2]

(b) Award [2 max].

As Book\_Title attribute is String/Varchar;

It does not allow many validation checks (like range check etc);

[2]

(c) Award [1 max].

Seeking the truth;

[1]

(d) Award [4 max].

Award [1] for selection of both Publisher\_Name and Book\_Title from the two respective tables.

Award [1] for making INNER JOIN of the Publisher\_Name from both tables-Publisher and Author.

Award [1] for the correct test ON Author\_Num from both tables-Author and Book.

Award [1] for the correct test of equity of Publisher\_Name.

```

SELECT Publisher.Publisher_Name, Book.Book_Title FROM Author
INNER JOIN Book ON PUBLISHER. Publisher_Name =
Author.Publisher_Name, ON Author.Author_Num = Book.Author_Num
WHERE Publisher.Publisher_Name = "Orlando Crux";
  
```

[4]

(e) Award [2 max].

Helps the searching of a family name for example rather than a "like" name search;

So, making data into the smallest possible unit helps quicker searches;

[2]

(f) Award [2 max].

Each user sees a fixed view of the data;

This may include visible changes made by the user / the user's own transactions and transactions of other users;

[2]

(g) Award [2 max].

When a field value changes multiple occurrences must be updated;

For example, if a publisher moves, we'll need to change the values for City and Country in multiple records;

Problem occurs if we forget to change the values in any of the records;

The database would then have data inconsistency;

[2]

2. (a) **Award [3 max].**  
 The ability of a database to allow multiple teachers to affect multiple transactions;  
 Allowing concurrent processing while ensuring transaction isolation;  
 Thus, ensuring the update of one teacher does not affect the update of another teacher;  
 While one transaction (by a teacher) is accessing a resource from a shared folder, it places a lock, an access restriction, on the resource, controlling the level of access allowed by another transaction by another teacher; [3]
- (b) **Award [4 max].**  
**Award [1] for identifying a way of maintaining data security and [1] for a development up to [2 max]**  
**Mark as [2] and [2]**
- Minimizing permissions;  
 Restrict users to have permission only to the means to do their job. Some can view, modify and insert some only view etc;
- Auditing changes;  
 Log changes made to teachers and permissions through auditing. This gives a trail to follow should you have problems. Without authorization no one gets grant of permissions;
- Minimizing table access;  
 Isolate the teachers from the data tables they do not need / Create views and user defined functions to support user access requirements and not give access to the tables; [4]
- (c) (i) **Award [2 max].**  
**Award [1] for identifying a way of maintaining data security and [1] for a development up to [2 max].**
- Deferred update;  
 does not physically update the database on disk until a transaction has reached its commit point/if a transaction fails before reaching its commit point, it will not have changed the database in any way so UNDO is not required;
- Shadow paging;  
 When a page is to be modified, a shadow page is allocated in which changes are made;  
 When it is ready to become durable, all pages that refer to original are updated to refer new replacement page;
- Back-up;  
 Back-up copies of the entire database is done to ensure the database is at the most updated version of the original; [2]

- (ii) *Award [3 max].  
Award [1] for the method, award [1] for the explanation and [1] for the example up to [3 max].*

Data masking or data obfuscation;  
is the process of hiding original data with random characters;  
eg: suppressing certain characters in the student address, student id *etc*;

Data encryption;  
Conversion of data into non-readable gibberish creates highly secure results such as scrambling the student\_ID;  
The only way to gain access to the data is to unlock it with a key or password which only those authorized can access;

**[3]**

3. (a) *Award [4 max].*  
 Applications interacting with the database are minimally affected;  
 When a fully normalized database structure is extended, to accommodate new types of data, database structure can remain largely or entirely unchanged;  
 So, the applications interacting with the database are minimally affected;
- Key dependent;  
 Every non-key column in every table is directly dependent on the key, the whole key and nothing but the key;  
 Thus making reduced redundancies, lesser anomalies and better efficiencies;  
*Mark as [2] and [2].* [4]
- (b) *Award [2 max].*  
 For First Normal Form, each attribute value should be atomic;  
 In the given example product\_Num, Pro\_Name, Unit\_Price and Qty is multivalued / All 4 tuples shown have multiple values in their first 4 attributes; [2]
- (c) *Award [8 max].*  
*Award [1] for each correct table up to [4 max].*  
*Award [1] for each correct primary key up to [4 max].*
- 3NF**
- Product\_Number  
 Product\_Number, Unit\_Price, Product\_Name
- Sales\_Person  
 Sales\_Person\_Number, Sales\_Person\_Name, Manager\_Number
- Manager  
 Manager\_Number, Manager\_Name
- Purchases  
 Purchase\_ID, Date\_And\_Time, Product\_Number, Sales\_Person\_Number [8]
- (d) *Award [2 max].*  
 You can enter foreign keys that do not match the corresponding primary key in the related table;  
 This could cause a lot of problems such as mismatched customer data and mismatched transaction records;
- Cascading update;  
 If the primary key for a record in the Managers table changes, all corresponding records in the Employees table are modified;
- Cascading delete;  
 If a record in the Managers table is deleted, all corresponding records in the Employees table are deleted; [2]
- (e) *Award [2 max].*  
 The combination of the two provides unique identifiers for the records of the table;  
 And that there is no single attribute that is able to uniquely identify a record; in a manner that will not lead to potential duplication of records;  
 It identifies exactly one record of the table, then that record shows the single value of each of the non-key attributes;  
 That is associated with the unique combination of the key attributes; [2]

**Option B – Modelling and simulation**4. (a) *Award [3 max].*

Variable	Data type	Range of values
Ocean surface temperature	Number, real	Between –5 and +30
Albedo	Number, integer	0–100 or 0–1
Sea ice area	number	$\geq 0$

**[3]**(b) *Award [4 max].*

Initialization – Original area of sea ice;  
 Initialization – Surface temperature change;  
 New sea ice area calculation;  
 Sea level change calculation;

*Example algorithm:*

OriginalSeaIceArea = 1000000

SurfaceTempChange = 0.04

NewSeaIceArea = OriginalSeaIceArea \* (1 - SurfaceTempChange)

SeaLevelChange = -(NewSeaIceArea - OriginalSeaIceArea) /

OriginalSeaIceArea \* 100 \* 20

**[4]**(c) (i) *Award [1 max].*960 000 (km<sup>2</sup>);**[1]**(ii) *Award [1 max].*

80 (mm);

**[1]**



(d) **Award [7 max].**

Initialization – Initial areas of Ice and water, and starting year;  
 Use of loop;  
 Loop parameters (limits, condition, increment, end statement correct);  
 Average albedo;  
 Rate of decrease calculation;  
 Area of ice update calculation;  
 Area of open water update calculation;  
 Output;

*Example algorithm:*

```
IceArea = 1000000
OpenArea = 1000000
Year = 2019
Loop While IceArea > 10000
  TotalArea = IceArea + OpenArea
  AveAlbedo = ((IceArea * 0.6) + (OpenArea * 0.1)) / (IceArea + OpenArea)
  Decrease = 0.3 / (AveAlbedo * AveAlbedo)
  // allow Decrease = 0.3 / AveAlbedo ^ 2
  IceArea = IceArea * (1 - (0.01 * Decrease))
  OpenArea = TotalArea - IceArea
  Year = Year + 2
End loop
Output "Date when there less than 10 000km2 of ice in the ocean
is " Year
```

[7]

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

Spreadsheets;  
 IDEs using code;

[2]

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

If the calculation of the rate of reduction of the sea ice is inaccurate the  
 calculation of the amount of sea ice remaining;  
 At a given time will turn out to be wrong;  
 So, work to correct the problems may be too little/too great;

The year in which the sea ice is predicted to be 10 000 km<sup>2</sup>;  
 Will be wrong;

So, ice coverage may be more/less than expected in the calculated year;

[3]

5. (a) **Award [4 max].**  
Data is entered into a rule-based environment;  
The rules may be kept the same and the nature of the data input may be varied;  
Or the data that is input may remain the same and the rules may be varied;  
Which allows for a range of possible scenarios to be investigated; [4]
- (b) **Award [3 max].**  
Life expectancy;  
Gender;  
Availability of life-extending treatments;  
Genetic information;
- Allow other appropriate answers.* [3]
- (c) **Award [5 max].**
- Example answer:*  
One ethical issue is invasion of privacy;  
to get the best quality model;  
sensitive personal data will need to be collected;  
trade-off between the benefits of this model and level of intrusion into people's lives;  
especially if the data is being shared with third parties; [5]
- (d) **Award [3 max].**  
Simulation may be used to handle uncertainty and provide ranges of expected outputs; eg repeatedly inputting data drawn from random samples of plausible input values;  
To look at the predicted spread of outcomes over time (consider the use of simulation in the analysis of queues);
- A simulation is considered to be a representation of a model over time;  
This means that the simulation can be used over a longer period of the development life cycle;  
It can be used to assist with stages such as the implementation stage; [3]

6. (a) The creation of a human interpretable image from data; [1]
- (b) *Award [2 max].*  
The characters are defined as mathematical models;  
They will need rendering to give a 3D effect;  
Each movement will need to be fluid;  
The animation is less interesting with flat figures;
- Allow mark for explanation of rendering.* [2]
- (c) *Award [6 max].*  
Rendering for non-interactive media such as animations is a much slower process than for interactive media/games;  
Rendering times for individual frames may vary from a few seconds to days depending on the complexity of the scene;  
Rendered frames are stored to a hard disk and then transferred to other media for playback;  
3D rendering is computationally resource hungry;  
Computer processing power has increased rapidly and greatly over the years;  
Allowing a much higher degree of photorealism / realistic rendering; [6]

**Option C – Web science**7. (a) **Award [2 max].**

Change/re-flow the layout of the page to suit different screen sizes/formats;  
 adjust font sizes;  
 adjust image sizes;  
 provide alternative menus / link options;

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

The code:

- uses SQL to query the `CATEGORY` table in a database, selecting all pairs of `<category_id, category_name>` ordered by `category_name`;
- stores the results of the query in a variable / array `$categoryqueryresult`;
- prepares HTML for a drop-down menu which consists of a list of option tags derived from iterating through each pair in `$categoryqueryresult`;
- sets the “value” attribute of each menu item to `category_id`;
- sets the “text” attribute of each menu item to `category_name`.

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

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

Include authoritative / high quality website content;  
 To attract other reputable sites to link to it / promote it in the search engine ranking;

Use appropriate use meta tags (eg keywords/descriptions);  
 To provide clear data for web-crawlers/robots to use when categorising the page;

Separate content from formatting (e.g. use of CSS etc.);  
 To allow search engines to index the content of the site more effectively;

Use site maps / site diagrams;  
 To aid indexing by web-crawlers/robots;

Include a robots.txt file in the page header;  
 To give instructions to web-crawlers/robots as to how to index and describe the various pages on the site;

(d) **Award [2 max].****Lossy compression**

Reduces the file-size by removing some of the data in the file;  
 Once removed, the data cannot be recovered;  
 This generally results in a loss of quality (eg picture resolution, audio frequency range);  
 Files compressed using lossy compression are used in their compressed form (eg images, video, audio);

**Lossless compression**

Reduces file size by looking for repeated patterns of data / redundant data and replacing those with a single shorter “token”;  
 The tokens are associated with the data they represent by using a dictionary added to the file;  
 Files must be decompressed before they can be used;  
 Decompression software reads the dictionary and replaces all the tokens with the original data they represent;  
 Files do not lose any of the data they contain when compressed / decompressed;

(e) *Award [3 max].*

Lossless compression reduces file size while preserving all the data;

Once decompressed, the pdf document will contain all the data in the original document;

Some pdf software allows for the automatic lossless compression of the document / the developers would not have to apply compression retrospectively;

It would be hard for a lossy compression algorithm to distinguish between data that can be removed (eg reducing the resolution of the images) and data that is necessary for the pdf documents to make sense (eg parts of the text);

Using lossy compression may result in an unusable/unreadable document;

*Accept answers that focus on why lossy compression would be unsuitable for the pdf files.*

8. (a) (i) *Award [1 max].*  
HTTPS / hypertext transport protocol secure;
- (ii) *Award [3 max].*  
The DNS looks up the domain name “home.cern” in its database;  
If it doesn’t have this string, it passes the query to another DNS according to defined rules;  
This process continues until either an IP address is passed back to the starting DNS or an error message is returned;  
The IP address (or error message) is sent back to the client that initiated the call to the DNS;

- (b) *Award [6 max].*  
*Mark as [3] and [3].*

Multiple copies of all or part of the data can be kept at different sites;  
This ensures that there is no single point of failure;  
and the redundant data helps to ensure against data loss;

Different computers on the grid can use different analysis and data visualization tools;  
This allows scientists to run whatever analysis tools best suit their own specialism/area of interest;  
Rather than being limited to the tools provided by CERN;

Analysis can be performed using distributed processing time/capacity;  
This reduces load and/or reliance on a centralized system;  
Allowing a greater number of processes to be run concurrently;

Computers on the grid can be in multiple time zones;  
This gives scientists more equitable access to data;  
And facilitates round-the-clock monitoring and the availability of expert support;

Resources can be distributed across the world rather than being held in one country;  
This may attract funding from governments for their own locally-based research;  
As they may see the benefits of international cooperation;

(c) *Award [6 max].*

**Benefits of CC licensing:**

CERN want their experimental results to be freely accessible (within specified limits);

Allows for the more rapid dissemination of data/information while preventing people from repackaging them and selling them as a commercial product;

May further the advance of scientific knowledge / be seen as an altruistic gesture;

No need to contact CERN about using the work / allows CERN to focus on their primary function, ie scientific research;

**Limitations of copyright:**

May be impossible to enforce;

Enforcement would require significant costs associated with hiring of lawyers etc;

It may not be possible to find all cases where work has been used without copyright permissions;

Plagiarism may occur outside of Switzerland where different copyright laws may exist;

*Candidates are not required to make comparisons with copyright, however credit should be given where valid limitations of copyright are explained.*

*Mark as [3] and [3].*

9. (a) **Award [1 max].**  
The ability of something to be extended or expanded from its initial state, eg software / file Formats / programming languages;  
The ability to add custom / user-defined elements (eg XML tags, plug-ins, add-ons);
- (b) **Award [2 max].**  
In the real world, computer systems and databases contain data in incompatible formats;  
XML data is stored in plain text format. This provides a software- and hardware-independent way of storing data / makes it much easier to create data that can be shared by different applications;  
XML makes it easier to expand or upgrade to new operating systems / applications / browsers;
- (c) **Award [2 max].**  
Interoperability is the ability of different computer systems (including operating systems and applications) to work cooperatively / share data;  
Open standards are standards that are publicly available and (normally) free to use;  
Open standards are one factor aiding interoperability;
- (d) **Award [2 max].**  
The Common Gateway Interface (CGI) is part of the Web's Hypertext Transfer Protocol (HTTP);  
CGI is a method or convention for passing data back and forth between the server and the application;  
A programmer can write a CGI application in a number of different languages.  
CGI provides a more efficient mechanism for data to be passed from the user's request to the application program (and back to the user);  
CGI is not dependent on the operating system used by the server. The methods / conventions remain the same;
- (e) **Award [2 max].**  
In a blog, only the owner can post an article / open a thread of discussion / start a theme;  
In a forum all registered participants can post an article / open a thread;
- In a blog, registered visitors may be allowed to comment but the blog owner may moderate the comments before displaying them;  
in a forum all registered users are allowed to comment (without moderation);
- In a blog users cannot edit or delete posts;  
in a forum there may be moderators who can edit or delete posts after they have been made;



(f) Award **[6 max]**.

**Note:** do not award a tick for each idea, use the markband and use best-fit to determine the level of the response.

### **Blog**

- allows the head librarian to post articles/entries that give readers a better idea of the issues/decisions affecting the library/the background context that affect decisions / may result in better informed and focused comments from readers;
- may foster a greater sense of participation / spirit of community / allow the head librarian to aggregate majority views;
- the ability of the head librarian to moderate posts may allow off-topic/unhelpful/offensive comments to be filtered-out / however this might also allow the head librarian to censor/modify comments that are legitimate but critical of library services/contrary to decisions that the library want to push-forward;

### **Forum**

- allow library users to raise issues that they find important rather than only commenting on issues raised by the head librarian / may allow greater head librarian to develop a greater awareness of issues affecting/affected by decisions;
- lack of moderation may allow users to raise controversial issues / however may also reduce ability of head librarian to filter-out off-topic/unhelpful/offensive posts;
- may oblige head librarian to engage in greater discussion / justification of actions / however excessive time might be spent clarifying issues / dispelling myths;

### **Both blog and forum**

- the comments/posts may not be reflective of the general/majority view / may be restricted to a biased/self-selecting sub-set of library users. This may influence the head librarian to make decisions that cater for the "vocal" minority;

### **[1–2 marks]**

A limited response that indicates very little understanding of the topic or the reason is not clear. Uses little or no appropriate subject specific terminology. No reference is made to the scenario in the stimulus material. The response is theoretical and descriptive.

### **[3–4 marks]**

A superficial analysis of why the increased engagement with library users through the blog and forum will assist the head librarian with decision making. There is some use of appropriate subject specific terminology in the response.

### **[5–6 marks]**

A discussion of why the increased engagement with library users through the blog and forum will assist the head librarian with decision making. Explicit and relevant references are made to the scenario in the stimulus material. There is appropriate use of subject specific terminology throughout the response.

**Option D – Object-oriented programming**

10. (a) *Award [1 max].*  
A method that allows/controls changes to a private (hidden) variable; [1]
- (b) *Award [1 max].*  
`boolean isFinals;` [1]
- (c) *Award [3 max].*  
The class `Swimmer` is the blueprint of a `Swimmer` object;  
An instantiation is the actual object filled with data;  
The class `Race` stores up to 8 different instantiated objects of the `Swimmer` class; [3]
- (d) (i) *Award [2 max].*  
*Award [1] for identifying an advantage and [1] for an elaboration of the advantage up to [2 max].*  
  
Aggregation reduces dependencies;  
and therefore reduces maintenance overhead; [2]
- (ii) *Award [2 max].*  
*Award [1] for identifying a disadvantage and [1] for an elaboration of the disadvantage up to [2 max].*  
  
Aggregation of swimmers in a `Race` object can cause issues with processing;  
eg when searching for all heats that a particular swimmer participates in; [2]
- (e) *Award [4 max].*  
*Award [1] for correct signature including parameters.*  
*Award [1] for assigning name and school.*  
*Award [1] for a (any) loop.*  
*Award [1] for assigning empty to `eventID[i]`.*  
*Award [1] for assigning 0 (or 0.0) to `time[i]`.* [4]
- Example answer:*  

```
public Swimmer(String name, String school)
{
    this.name = name;
    this.school = school;
    for(int i = 0, i < 5; i++)
    {
        eventID[i] = "empty";
        time[i] = 0;
    }
}
```
- (f) *Award [3 max].*  
Modern programming languages use Unicode to encode characters.  
Which uses 16 bits / has about 64 000 characters.  
As opposed to ASCII which uses 8 bits / has 256 characters. [3]

11. (a) **Award [3 max].**  
*Each method is defined within its own class.  
Each method is called within an object of that class.  
Therefore the compiler knows which method to use.* **[3]**
- (b) **Award [4 max].**  
**Award [1] for an advantage and [1] for an elaboration up to [2 max].**  
**Mark as [2] and [2].**
- It promotes code reuse;  
Because the parent object holds common data and action;
- It reduces maintenance overhead;  
Because you only have to update the parent; **[4]**
- (c) **Award [2 max].**  
**Award [1] for a clear understanding of method overriding and [1] for relating it to this situation up to [2 max].**
- Method overriding redefines/replaces a method from the inherited class;  
The constructor could only instantiate the `finals` object;  
The method `addSwimmers()` could fill `finals` directly;  
The method `fillFinals()` could do nothing; **[2]**

12. (a) **Award [3 max].**  
**Award [1]** for array of 8 slots with array name.  
**Award [1]** for correct entries (in any order).  
**Award [1]** for correct order.

swimmer	Bella	Andy	Eric	Idan	Duc	George	Karl	Hetty
	[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]

Do not penalize the lack of subscripts.

**[3]**

- (b) **Award [6 max].**  
**Award [1]** for correctly declaring 2 arrays of size 16.  
**Award [1]** for correct outer loop.  
**Award [1]** for correct inner loop.  
**Award [1]** for copying swimmer object.  
**Award [1]** for copying time.  
**Award [1]** for incrementing the index of the new arrays.

*Example answers:*

```
Swimmer[] tempSwim = new Swimmer[16];
double[] tempTime = new double[16];
int newIndex = 0;
for(int i = 0; i < 2; i++){
    for(int j = 0; j < 8; j++){
        tempSwim.swimmer[newIndex] = races[i].swimmer[j];
        tempTime.time[newIndex] = races[i].time[j];
        newIndex++;
    }
}
```

**[6]**

**Note:** that the question asks for all entries to be copied. However, do not penalize "efficient" solutions that avoid copying the null and 0 entries.

(c) (i) Bubblesort; [1]

(ii) Award [4 max].

Award [1] for stating an improvement and [1] for an elaboration up to [2 max].

Mark as [2] and [2].

Include a flag “swapped”;

That can help stop the outer loop if there is a pass through the inner loop with no swap;

Limit the inner loop by deducting the outer loop counter;

So that the sorted elements are no longer compared;

[4]

(d) Award [6 max].

Award [1] for correctly instantiating variables.

Award [1] for correct loop condition (*count* < 8).

Award [1] for checking for a 0 time (or null entry).

Award [1] for correctly copying.

Award [1] for incrementing *count* in the right place.

Award [1] for incrementing *k* in the right place.

Example answers:

```
int k = 0;
int count = 0;
while (count < 8) && (k < 16) {
    if (tempSwim[k] != 0) {
        finals.swimmer[count] = tempSwim[k];
        count++;
    }
    k++;
}
```

**Note:** Do not penalize for not including loop condition (*k* < 16)

[6]