Original marking scheme in **bold**, additional comments in *italics*

In general a lot of answers were muddled and some completely incoherent. Being able to write grammatical English under time pressure is a prerequisite for most graduate-level jobs. Also, failure to read the questions properly (despite many warnings during the course) was common. The marking does not really reflect this, and with hindsight was overly generous.

Since this is based on the marking scheme provided for the benefit of reviewers rather than students, some of the standard answers are rather terse, and in a few cases more complete answers would be required for full marks. Where this is the case I’ve tried to indicate it in the comments.

Question 1. This question is **COMPULSORY**

a) State four reasons why design patterns are important in object-oriented software development.  

   *Provide tried and tested solutions to common software design problems*  
   *Provide a language which allow experiences developers to communicate efficiently*  
   *Provide a framework for discussing design tradeoffs*  
   *(and any other reasonable points)*

   A lot of people were confused between (GoF) design patterns and GRASP patterns. Some people didn’t even seem to know what design patterns ever were.

b) “The server returns copies of the question paper created by a **Factory** which is a **Singleton**”. Explain this statement and relate it to your answer to question 1a.

   Instead of creating copies of QuestionPaper objects directly, this task is delegated to a separate factory class, which will create them. [1] This provides a separation of concerns and makes it easy to create exam papers flexibly, for instance we might randomly or adaptively select from a question bank, possible giving different papers to different students. [1] We only even need one instance of this factory class, hence it’s a singleton. [1] Design patterns provide a common language for designers (should be included in the answer to 1.1) so for instance here an important design decision is conveyed in a single sentence [1]

   A lot of people failed to read the question properly, and answered it as if the question papers, rather than the factory, was the singleton. This doesn’t make sense (even Word can see that the previous sentence is ungrammatical!).
c) Show the important elements of this class in Java syntax (4 marks)

```java
public class QuestionPaperFactory {

    private static QuestionPaperFactory instance; [1]
    // Constructor is private so we can only create instances internally
    private QuestionPaperFactory() { … } [1 bonus]

    // Eager instantiation is also acceptable
    public static QuestionPaperFactory getInstance() { [1]
        if (instance == null) instance = new QuestionPaperFactory(); [1]
        return instance;
    }

    // Methods to create question papers. [or similar, 1]

}
```

There were only five answers which got 4 marks. Contributing factors were: confusion about which is the singleton, as above, a tendency to hallucinate the presence of adaptors because they were what the factory created last time out, and in a few cases use of the reflection-based version of singleton (fine in itself) resulting in confusion about the rest of it (not so).

d) Suppose the application is being extended so that it will accept question papers written in a variety of different formats and convert those to the format used by the exam software. Draw a UML class diagrams showing how the Adapter pattern can be used to organise this part of the application. (4 marks)


Note; in practice there will be many variations and this simplistic marking scheme will not always work.

By and large people either knew the adaptor pattern or they didn’t. As usual there were some misuses of UML notation and clutter added to the diagrams, but this wasn’t too bad.

e) Explain how the Factory and Adapter patterns are related to GRASP principles. For full marks you should include four different GRASP principles in your answer. (4 marks)

High cohesion, e.g a Factory creates objects and does nothing else.
Low coupling, e.g. Adapter decouples code within the application from external question formats
Both are Pure Fabrications – they are there to improve the design and are not related to domain classes
Adapter makes use of Polymorphism to provide Protected Variations
1 mark for each, or for other valid points

This should be really easy so I marked it fairly strictly. Answers varied in length from about 300 words – obviously far too much for 4 marks – to 11, obviously far too few. (I intended to use the word count feature as in the tests, but couldn’t because it’s buggy. I generally used 25 words per mark as the maximum).

Question 2

a) State four important principles of Agile software development (4 marks)

The easiest way to answer is to quote the agile manifesto. Value:

Individuals and interactions over processes and tools
Working software over comprehensive documentation (or minimise ceremony)
Customer collaboration over contract negotiation
Responding to change over following a plan

1 for each or similar principles.

This was answered very well in general.

b). Briefly explain the relationship between the Unified Process and Agile development (2 marks)

A good answer is:

The UP is, like Agile methods, iterative and emphasises engagement with stakeholders. [1] It specifies many artefacts which can be produced, but all, except the code, are optional; hence the UP can be applied in a Agile way. [1]

In this, as in all questions relating to the UP, many people reproduced various facts about the UP such as the four phases. This does not answer the question. This resulted in a lot of overly long answers which got at most 1/2.

c) State four different groups of stakeholders, other than students, in the exam software, and what their principal concerns will be. (4 marks)

e.g.
University Management will be concerned that the software is delivered on time and will provide value for money.
The Exams office will be concerned that online exams will fit in with their existing procedures.
Academics will be concerned that they will be able to set and mark exams easily.
Technical support will be concerned about how easily the system can be deployed and managed.

Most people managed to find four stakeholders, but the things stated as “principal concerns” were often just functional requirements – sometimes rather minor ones. This is crucial in real projects – you have to recognise the concerns of the stakeholders, and be able to address them, or your project doesn’t happen.

Question 2 continues over the page

d). A change in University management has resulted in a drastic scaling down of your project. Instead of the team you were expecting you have one full time software developer (from a country where the higher education system is very different from that in the UK) and your contribution will be limited by other duties. You still have to produce working software though. In this situation, which of the following artifacts would you choose to produce, and which would you omit? Your choices do not have to match those made in the real project so long as you justify them.
(2 marks each = 10 marks)

Only answers which explicitly related to the context above got full marks. Telling my why, e.g. a Domain model is a Good Thing in general was not adequate.

i A vision document

No. The information contained in a vision document is usually available elsewhere, typically in a funding document. The vision for the project can be communicated to the developer f2f as necessary. A lot of people still thought a vision document was good idea. Apart from the considerations above, it is not actually a particularly low-cost artefact. If you look at the example is Larman there’s actually quite a lot of it.

ii A domain model

Probably yes., since the developer is unfamiliar with the domain, and a domain model is generally low cost high value.

Most people agreed, although as mentioned above many answers were too generic.

iii A glossary
Probably yes for the same reasons. In particular the domain has a number of apparently simple but ambiguous terms e.g. “Marks” and “Exam”

Likewise.

iv Casual format use cases

Yes because it’s important to understand requirements from a users’ perspective; considerations similar to ii and iii above.

Some answers got bogged down in comparing casual and brief format, which doesn’t help in answering the question.

v Fully dressed use cases

Probably not because these are expensive to produce and vulnerable to change. A few might be useful if they will correspond to important end-user procedures such as invigilating exams.

Unless there was some explicit justification for having them, as above, there were not marks for advocating them. In practice we have never seriously considered producing them, they really are very expensive.

Question 3.

a) Explain why and when use cases are typically used in an iterative software development process such as the UP. Explain the role of use case diagrams in developing use cases.

(4 marks)

A good answer is:

UCs provide descriptions of functional requirements from a users’ perspective. [1] Using them rather than lists of features of the software increases the chance that the software will actually meet the users’ requirements. [1] They are produced throughout development, although the majority of the work is towards the beginning of the project. [1] UCs are text descriptions; the UCDs just give an overview of the UCs and are not an end in themselves, so if uses at all should be kept simple. [1]

Note that the question is about UCs in iterative SW development in general, not just in the UP. It seeks understanding of requirements issues, not formulaic answers about UP phases. In particular defining a particular point at which new UCs do not arise misses the whole point about changing requirements. Remarkably, very few people actually knew that a UC diagram is (see Larman p90).

b) Suppose that the exam software has an administration tool which has a number of functions, including ones in the following three categories:
• File management: upload and download of exam papers, standard answers and student answers to/from the server.
• User management – adding and amending user details, registering students for exams etc.
• Exam setup: setting parameters such as whether a test is timed or untimed, formal or informal, how often backups are made etc. For each assessment an HTML “entry page” is generated which encodes these parameters.

For each of these functions, describe a relevant use case in brief format (no more than 50 words). Note: you will not be penalised if you make reasonable assumptions about the operation of the tool which happen to be incorrect. (4 marks each = 12 marks)

Note: the following indicates the style required and reflects the (somewhat crude) behaviour of the real system. Use cases written in similar style under different, reasonable, assumptions are fine.

Upload exam: the administrator loads an exam file from local filestore onto the server, which checks whether the ID of the file matches an existing exam. If it does the administrator is given the option to overwrite the existing exam (which they must confirm) or use a new ID. The administrator then uploads the standard answer for that exam, for use in marking.

Register student: the administrator enters the student ID, password, and real name, and any special requirements such as extra time. The system checks whether the student ID already exists; if it does the administrator is given the option to either change the student information or use a different ID. The student data is added to the data on the server.

Set up exam: the administrator selects an exam which is already present on the server. They specify the exam timing, entry mode and backup parameters. If the exam is to be available via a web browser, then once all parameters have been set, the administrator asks for an HTML entry page to be generated, and the system responds with the URL for that page.

The basic problem with answers to this question is that most of them were not use cases – this was reflected by the fact that almost no answer included a UC name. Only the exam setup can be considered can as a single UC, the others are broad categories of functionality. Many answers were little more than restatements of the information in the question, and few would pass the EBP test.

c) Suggest four important non-functional requirements related to this tool, in at least three “URPS+” categories. (4 marks)

e.g.

Very high data integrity (corrupted data would be very bad) (reliability)
User interface optimised for efficient use by expert users (usability)
Confirmation and feedback on important operations (usability)
Response time of no more than 2 seconds except for operations involving large amounts of data.
(performance)

Answers to this were generally ok although many of them could apply to almost any tool. Few people thought carefully enough about it to realise that the tool should have a UI optimised for expert users (trained administrators) rather than merely being “easy to use”.

Question 4

a) What is the purpose of domain modelling? Your answer should include the relationship between domain classes and design classes, and the factors which influence the amount of effort worth spending on domain modelling. 5 marks

A good answer is:

Domain modelling both helps us understand the domain and suggests objects and interactions which may have close parallels in the software. [1] Design classes are not the same as domain classes, but they are often motivated by them, and often have the same names and attributes (mapmaker principle). [1] This lowered representational gap is what makes OO software development the One True Way © [1] The effort indicated in building a domain model depends on common-sense factors such as the size of the project, the degree of familiarity of the developers with the domain, and whether something similar already exists, always bearing in mind that you understand the domain less well than you think you do. [2]

This was the least popular question with only 14 answers, but it was by far the best-answered question on the paper – well done to those who did it!

b) Consider the following description of the process which is being used to prepare traditional paper exams in the current academic year.

“The course lecturers prepare questions using e.g. Word or LaTeX, and compose them into draft question papers in a standard format. They provide marking schemes which give the standard answers and a very detailed description of how the marks will allocated. (The extra detail in the marking schemes is an attempt to compensate for the impracticality of giving individual feedback on paper scripts)

The office staff prepare a rubric sheet for each exam paper which is prepended to the document provided by the lecturers. The paper is then sent with the marking scheme to an internal moderator for review. Once the internal review process is complete, the exam and marking scheme are sent to an external examiner who also reviews them. All the documents is kept in a pack which includes a cover sheet recording signatures and dates to show that the steps in
the process, including modifications to the exam or marking scheme, have been completed.”

Draw a class diagram to represent the significant domain classes suggested by this description and their important relationships and attributes. (7 marks)

Many possibilities, but should include: Question (since prepared individually) as well as QuestionPaper, MarkingScheme, CoverSheet and RubricSheet probably Pack. It’s important to distinguish between the cover sheet (where the stages of the process are signed off) and the rubric sheet. Course is implied. Including the actors, and even the Office, as domain classes is also reasonable in this example.

The students tend to draw cluttered domain models with extraneous classes too much detail, hence full marks only for a clear and truly informative diagram. They also tend to have a student-centric view of everything, so solutions which include a Student class will be marked down significantly.

The diagrams were generally very good – a couple got full marks and several nearly so – they were such that you could really work from them, hard to do under exam conditions, so well done.

c) To what extent would these domain classes correspond to design classes in an online examination system? (4 marks)

The basic classes, Question, QuestionPaper MarkingScheme, RubricSheet etc. would correspond very well. The online version would need to have something corresponding to the cover sheet. Actors and other peripheral entities would not. Answer will depend on what they included in the diagram.

Some of the answers were a bit woffly but generally this too was well answered.

d). Suggest four ways in which the dynamic aspects of the process could be improved in an online examination system (4 marks)

Clerical checking – that the marks add up etc. – and other consistency checks could be automated. All the “paperwork” could be online. Version control could be provided. The system could track where papers are in the process and even send reminders automatically (that would be really popular!) Internal and external moderation could happen in parallel. Marks for anything sensible.

Again answers were generally good, but tended to be a bit verbose. The following answer was exceptional in stating four key points very concisely:

“The rubric sheet could be automatically produced upon exam completion. [1] The sending of the documents could also be automated if the information about who will moderate the
papers is provided in advance. [1] The extra detail in the marking scheme could be feedback on the question itself. [1] The cover sheet could be replaced by automatically highlighting modifications to exams/marking scheme with a date of change. [1] “

The third point in particular shows a real understanding of what’s going on.

Question 5

a). Briefly explain the role of GRASP patterns in object-oriented software development. (3 marks)

A good answer is

They provide a set of principles for assigning responsibilities to classes, the most difficult skill in OO software development. [1] Like all patterns they form a language which helps developers to communicate [1]. The form the “building blocks” for design patterns. [1]

Answers with examples are also good.

Answers to this were generally ok, except there was a tendency to give lists of GRASP patterns which didn’t fit the requirement to “explain” and made the answers less brief.

b). Questions in the exam software may have sub-questions and sub-sub questions etc, and individual part-questions may be of various types (e.g. multiple choice, text, diagrams). Explain how the Composite design pattern can be used to organise the classes representing questions. (3 marks)

There will be an abstract Question class, with a CompositeQuestion subclass. [1] A CompositeQuestion will contain Questions, so the result is a tree structure of arbitrary depth. [1]. Actual question classes such as MCQ or TextQuestion will either be direct subclasses of Question, or of an abstract AtomicQuestion class. [1]

A curious feature of answers to this question is that a number of people said that the abstract Question class and/or the CompositeQuestion class a Pure Fabrications. This they are most definitely not, they are clearly identifiable in the domain.

c). For each of the following GRASP principles, explain how the use of Composite described above is consistent with it. (2 marks each = 10 marks)

Only answers referring to specific classes were acceptable.

i. High Cohesion
Each class represents a single well-defined entity, e.g. Question has just those attributes common to all questions (e.g. question text and marks allocated.)

A scary number of people failed to answer this coherently – it’s the most fundamental principle of OOD.

ii. Low Coupling

External code is coupled only to the Question class which will have a very simple interface. The design has low coupling internally to, for example the Question subclasses are coupled only to Question (and not vice-versa).

Most answers covered either the external coupling or the internal but only a couple covered both.

iii. Information Expert

The design makes it easy to ensure that operations are put in the classes which have the information to carry them out. For instance the getMarksAllocated() method naturally goes in Question, and getCorrectOption() in MCQ.

Answers ok, except for a few people who didn’t understand Information Expert and waffled.

iv. Polymorphism

Obviously polymorphism is used in the design in the form of Question and its subclasses. This leads to the benefits of low coupling, high cohesion etc. described above and also...

v. Protected Variations

... protects against variation. If another Question subclass is added, or the functionality of one of them changes, the rest of the code is not affecting – in fact it doesn’t even need to be recompiled.

This and iv were generally answered ok, although some of the answers were too brief/cryptic/waffl/genericy to get full marks.

d). Explain how a Controller could be used to present student answers to a marker. Your answer should suggest what kind of controller would be appropriate. (4 marks)

Note: an answer to the specific question is required, not just an explanation of what a controller is.
A Controller is a Pure Fabrication which decouples the user interface (view) of an application from the underlying data structures (model). [1] There are two kinds of controller. A Use Case Controller is derived from a particular use case, in this case Take Exam. [1] A Façade controller deals with the entire user interface of the application. [1]. In this case a Façade controller is probably best as the student has many options when taking an exam, they are not following a prescribed sequence of steps. [1]

(Arguments in favour of a UCC are also acceptable).

Since a question like this appears every year, the answers were very disappointing – nobody got full marks. It’s hard to generalise here, each answer had different deficiencies, so all I can suggest is to read the standard answer above carefully.