Version : 1.0 0107

ASSESSMENT and QUALIFICATIONS ALLIANCE

## General Certificate of Education

# Mathematics 6360

## MD02 Decision 2

# Mark Scheme

*2007 examination - January series*

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.



Set and published by the Assessment and Qualifications Alliance.

The Assessment and Qualifications Alliance (AQA) is a company limited by guarantee registered in England and Wales (company number 3644723) and a registered charity (registered charity number 1073334).
Registered address: AQA, Devas Street, Manchester M15 6EX
*Dr Michael Cresswell Director General*

## Key to mark scheme and abbreviations used in marking

| | |
|---|---|
| M | mark is for method |
| m or dM | mark is dependent on one or more M marks and is for method |
| A | mark is dependent on M or m marks and is for accuracy |
| B | mark is independent of M or m marks and is for method and accuracy |
| E | mark is for explanation |

| | | | |
|---|---|---|---|
| √or ft or F | follow through from previous incorrect result | MC | mis-copy |
| CAO | correct answer only | MR | mis-read |
| CSO | correct solution only | RA | required accuracy |
| AWFW | anything which falls within | FW | further work |
| AWRT | anything which rounds to | ISW | ignore subsequent work |
| ACF | any correct form | FIW | from incorrect work |
| AG | answer given | BOD | given benefit of doubt |
| SC | special case | WR | work replaced by candidate |
| OE | or equivalent | FB | formulae book |
| A2,1 | 2 or 1 (or 0) accuracy marks | NOS | not on scheme |
| –*x* EE | deduct *x* marks for each error | G | graph |
| NMS | no method shown | c | candidate |
| PI | possibly implied | sf | significant figure(s) |
| SCA | substantially correct approach | dp | decimal place(s) |

**No Method Shown**

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded. However, there are situations in some units where part marks would be appropriate, particularly when similar techniques are involved. Your Principal Examiner will alert you to these and details will be provided on the mark scheme.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn **no marks**.

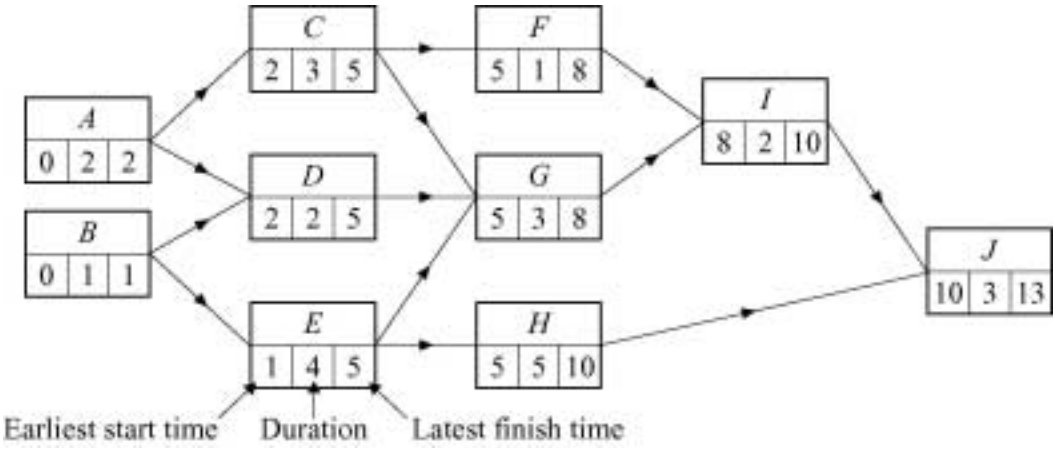
Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

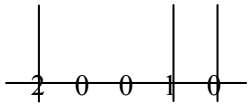
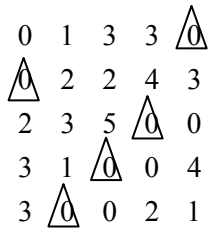
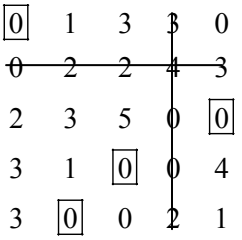
**Otherwise we require evidence of a correct method for any marks to be awarded.**

Jan 07

**MD02**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **1(a)** | Network attempted | M1 | | SCA |
| | up to 2 slips (boxes or arrows) | A1 | | |
| | correct network | A1 | 3 | |
| |  | | | |
| **(b)** | Forward pass | M1 | | |
| | correct | A1 | 2 | |
| **(c)** | Backward pass | M1 | | |
| | correct | A1 | 2 | |
| **(d)** | Minimum completion time: 13 weeks | B1 | | |
| | Critical paths: *ACGIJ* | B1 | | |
| | *BEGIJ* | B1 | | |
| | *BEHJ* | B1 | 4 | |
| | **Total** | | **11** | |

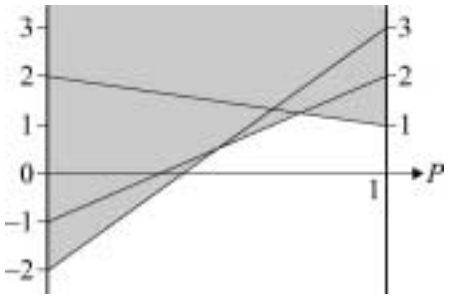
**MD02 (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **2(a)** | Hungarian algorithm **minimises** | E1 | | |
| | $15 - x$ gives measure of criteria NOT met which need minimising in order to maximise scores | E1 | 2 | idea of high becoming low, etc. |
| **(b)** | 2 4 6 5 2<br>0 3 3 4 3<br>3 5 7 1 1<br>4 3 2 1 5<br>3 1 1 2 1 | B1 | | array giving $15 - x$ |
| | 0 2 4 3 0<br>0 3 3 4 3<br>2 4 6 0 0<br>3 2 1 0 4<br>2 0 0 1 0 | M1<br>A1 | | reduce rows (or columns then rows)<br>reduced array correct |
| | Zeros can be covered with only **4 lines** so adjustment needed | E1 | |  <br>augmented array |
| | Reduction by subtracting 1 from each uncovered element and adding 1 to each element at intersection of two lines | M1<br>A1 | |  |
| | Matching on particular zeros<br>Alex ↔ (5) Don ↔ (3)<br>Bill ↔ (1) Ed ↔ (2)<br>Cath ↔ (4) | M1<br>A1 | 8 | |
| | If adjustment **not** done correctly and matching made, award B1 for 3 correct and B1 for rest correct | | | Award last 2 marks in whichever way benefits candidate most |
| **(c)** | Deleting row 2 and column 4 either in final matrix or reworking<br>Final solution:<br>A ↔ (1) C ↔ (5)<br>D ↔ (3) E ↔ (2) | M1<br>A1<br>A1 | 3 |  |
| | If no method award B2 if matching is all correct | | | |
| | **Total** | | **13** | |

**MD02 (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **3(a)** | P $x$ $y$ $z$ $s$ $t$ Value<br>1 $-5$ $-8$ $-7$ 0 0 0<br>0 3 2 1 1 0 12<br>0 2 (4) 5 0 1 16 | M1<br>A2 | 3 | SCA<br>$-1$ EE |
| **(b)(i)** | $\frac{12}{2}=6$; $\frac{16}{4}=4$ and $4<6$ | E1 | 1 | |
| **(ii)** | 1 $-1$ 0 3 0 2 32<br>0 (2) 0 $-1\frac{1}{2}$ 1 $-\frac{1}{2}$ 4<br>0 $\frac{1}{2}$ 1 $1\frac{1}{4}$ 0 $\frac{1}{4}$ 4 | M1<br>A1<br>A1 | | using 4 as pivot and possibly dividing third row by 4<br>top row correct<br>second row correct; may have 0 2 4 5 0 1 16 |
| | choice of pivot from $x$-column | M1 | | pivot = (2) identified and used |
| | 1 0 0 $2\frac{1}{4}$ $\frac{1}{2}$ $1\frac{3}{4}$ 34<br>0 1 0 $-\frac{3}{4}$ $\frac{1}{2}$ $-\frac{1}{4}$ 2<br>0 0 1 $1\frac{5}{8}$ $-\frac{1}{4}$ $\frac{3}{8}$ 3 | m1<br>A1 | 6 | row operations<br>correct or scaled up 0 0 4 $6\frac{1}{2}$ $-1$ $1\frac{1}{2}$ 12 |
| **(iii)** | Max $P=34$<br>$x=2,\ y=3,\ z=0$ | B1√<br>B1 | 2 | all correct |
| **(iv)** | Yes - no negative values in first row | E1√ | 1 | no – if negatives in top row |
| | **Total** | | **13** | |

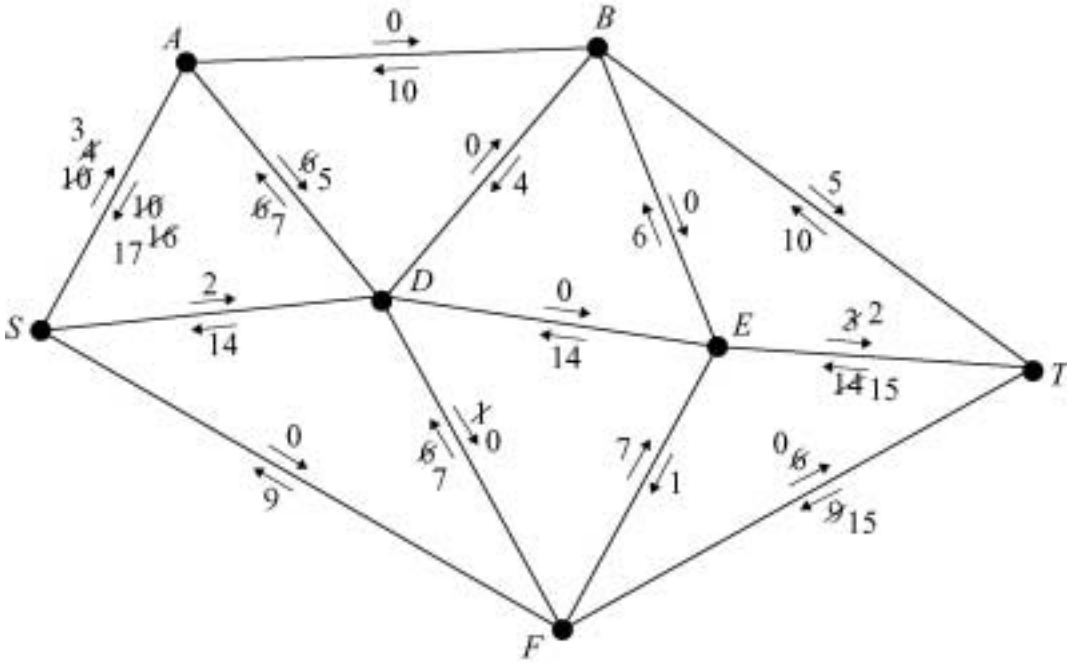
**MD02 (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **4(a)(i)** | Row min<br>$-4$<br>$-2$<br>$-1$<br>Col max 5 $-1$ 3 | M1<br><br><br><br>A1 | | Attempt at row minimum and column maximum<br><br><br><br>all figures correct |
| | min (col max) = max (row min)<br>$\Rightarrow$ stable solution | E1 | 3 | |
| **(ii)** | Ros plays III and Col plays Y<br>value of game = $-1$ | B1<br>B1 | 2 | |
| **(b)(i)** | Ros plays $R_1$ with probability $p$ and $R_2$ with probability $1-p$<br><br>Expected gains when Col plays:<br>$C_1 : 3p-2(1-p) = 5p-2$<br>$C_2 : 2p-(1-p) = 3p-1$<br>$C_3 : p+2(1-p) = 2-p$ | <br><br><br><br>M1<br>A1 | | <br><br><br><br>attempt at least 2<br>correct unsimplified |
| | Plot expected gains against $p$ for $0 \le p \le 1$ | M1 | | |
| |  | A1 | | correct (must see 0 or 1 on $P$ axis, or implied by their numbers)<br>A0 if not possible to see highest point of region being correct |
| | Choose highest point of region below lines $\Rightarrow 3p-1 = 2-p$ | M1 | | must be this pair of lines or their highest point |
| | leading to $p = \frac{3}{4}$ | A1 | | |
| | Therefore Ros plays $R_1$ with prob $\frac{3}{4}$<br>and plays $R_2$ with prob $\frac{1}{4}$ | B1√ | 7 | ft their $p$ from any lines |
| **(ii)** | Value of game = $3 \times \frac{3}{4} - 1$<br>or $\left(2 - \frac{3}{4}\right) = 1\frac{1}{4}$ | B1 | 1 | |
| | **Total** | | **13** | |

**MD02 (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **5(a)** | *SAET* has least day's sunshine of 5 hours whereas for *SACT* least value is only 4 hours | M1<br>A1 | 2 | Reasonable understanding<br>Mention of 4 and 5 hours and clear idea that minimum is larger in *SAET* |
| **(b)** | Stage / Initial State / Action / Value | M1 | | General idea of stage and state |
| | 1 / *C* / *CT* / 7*<br>*D* / *DT* / 9*<br>*E* / *ET* / 5* | A1 | | First stage correct (may be reversed) |
| | 2 / *A* / *AC* / min (4, 7) = 4<br>*AD* / min (4, 9) = 4<br>*AE* / min (5, 5) = 5* | M1<br>m1 | | Finding least value from 2 legs<br>Finding max of minima (star values) |
| | *B* / *BC* / min (6, 7) = 6*<br>*BD* / min (5, 9) = 5<br>*BE* / min (7, 5) = 5 | A1 | | All values in second stage correct |
| | 3 / *S* / *SA* / min (9, 5) = 5<br>*SB* / min (8, 6) = 6* | A1 | | All values in third stage correct |
| | | A1 | | All values correct (inc max of min all correct) **and** minimum comparison clearly shown at each stage, particularly (9, 5) and (8, 6) in third stage |
| | Maximin route is *SBCT* | B1 | 8 | Award B1 even without dynamic programming |
| | **Total** | | **10** | |

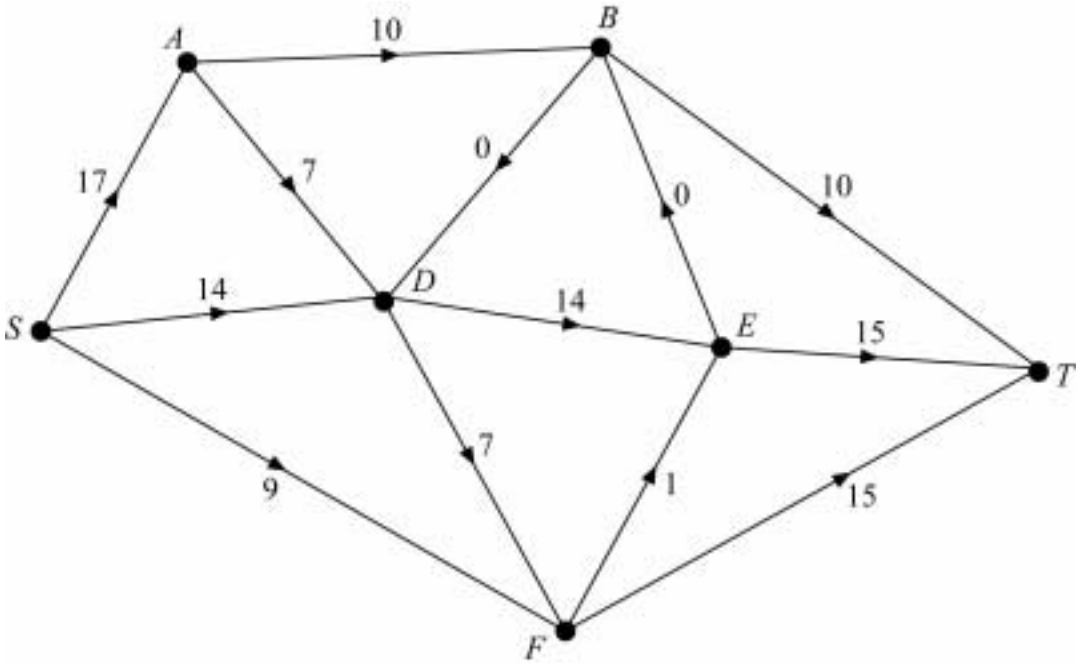
**MD02 (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **6(a)(i)** | 15 + 0 + 14 + 7 + 9 = 45 | B1 | 1 | |
| **(ii)** | Maximum flow ≤ 45 | M1 | | ≤ their value or < 45 |
| | | A1 | 2 | correct |
| **(b)** | *SABT* flow 10<br>*SDET* flow 14 | B1 | | one correct |
| | *SFT* flow 9 | B1 | 2 | two more correct |
| | (may appear in table below) | | | |
| **(c)(i)** |  | | | |
| | Additional route | M1 | | |
| | with correct flow | A1 | | |
| | one more correct route and flow | A1 | | |
| | table complete | A1 | | correct total flow of 40 |
| | correct use of potential and used flows | M1 | | on network (may use double edges) |
| | values correctly updated | A1 | 6 | **strict** |

| Route | Flow |
|---|---|
| *SABT* | 10 |
| *SDET* | 14 |
| *SFT* | 9 |
| *SADFT* | 6 |
| *SADFET* | 1 |

several possibilities

**MD02 (cont)**

| Q | Solution | Marks | Total | Comments |
|---|---|---|---|---|
| **6 (cont)** **(c)(ii)** |   | | | |
| | Maximum flow = 40 | B1 | | |
| | Network showing flow of 40 | B1 | 2 | |
| **(iii)** | Cut through saturated arcs *AB*, *BD*, *DE*, *DF*, *SF* | M1 | | |
| | Minimum cut shown to be 40 with statement linking to maximum flow | A1 | 2 | |
| | **Total** | | **15** | |
| | **TOTAL** | | **75** | |