Examiners' reports 2013–14

CO3343 Computing art and image effects – Zone B

General remarks

This is an ambitious course that attempts to approach – from a common perspective – a wide spectrum of concepts that span from the investigation of the way artists model aspects of their work and the emotional effects intended; to technical issues of image processing, computer graphics and the underlying mathematics. For this reason, a carefully balanced approach is required from students during their study of this subject. As in previous years, most candidates appeared to be more confident with the technical parts, focusing less on the artistic side; while a few demonstrated the opposite; this has been reflected in the corresponding discrepancies in the marks achieved.

Candidates this year did not generally manage to perform well. More specifically, there was complete lack of first-class attempts, while only a few candidates managed to demonstrate a good level of understanding of the concepts covered in the course. Furthermore, there were a number of borderline attempts but the majority of submissions were, unfortunately, too weak to attract a passing mark.

A common problem was that candidates did not provide clear and concise explanations. Practising clarity in explanations is an area worth focusing upon in revision and examination practice, and it should build upon the skills developed in earlier coursework assignments and examinations. Candidates are also reminded that, unless otherwise specified in the question, prose answers should be in the form of coherent text, such as a short essay, and not just a set of bullet points or notes.

Finally, there was a noticeable imbalance between the popularity of questions and the average marks that they attracted. This could be an indication of improper selection of questions to answer. Candidates are always advised to allocate a short period of time at the beginning of the examination to carefully read and assess the difficulty of all questions before making their choices.

Comments on specific questions

Question 1

This was the most popular question but attracted the second lowest average mark, with the majority of candidates not achieving a passing score. Parts (a) and (b) are covered in the subject guide and the directed reading; while part (c) required application of bookwork knowledge to an unseen problem.

Part (a)

The viewer perceives the perspective effect as most natural when viewing the picture at right angles to its plane, along a line that passes through the vanishing point, as this is a consequence of the perspective geometry and thence the pictorial construction. Hence, if the vanishing point is outside the picture boundary, the viewer's eye will not be directly opposite any part of the picture when normal to the vanishing point; while if the vanishing point is within the picture boundary, the viewer will necessarily be directly in front of the picture for a normal perspective view.

An example of a painting with this main vanishing point within the boundary of the picture is 'Virgin and Child' by Massaccio (Figure 1.5 in the subject guide; although Figure 1.6 in the subject guide – 'The Flagellation of Christ' by Piero della Francesca – would also be suitable).

One feature to note is that the normal, receding lines of features in the painting all point inward as depth increases; in this case converging on the toes of the child's right foot as the vanishing point.

Unfortunately, most candidates failed to identify what is probably the simplest reason: when the vanishing point is within the picture frame, the viewer will have a correct perception of depth while standing in front of it.

Furthermore, the notion of the vanishing point seemed to confuse some candidates who described it as 'the place where the artist was drawing from'.

Part (b)

This was essentially bookwork based on sections 1.2.1 and 2.1.5 of the subject guide. Most candidates demonstrated confusion regarding the notions of stereo vision; for example, some suggesting the existence of four or five vanishing points:

i. Sample answer on p.16 of the subject guide.

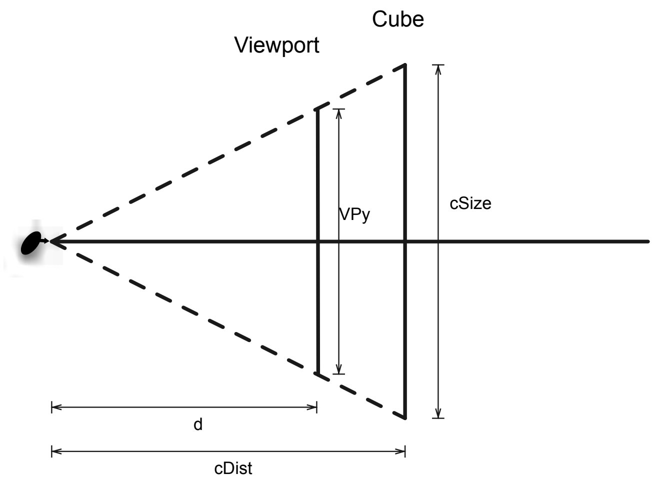
ii. Bi-directional linear and curvilinear perspective were to be mentioned here. (See subject guide section 1.2.1, p.16 and section 2.1.5, pp.35–36); while the illustration requested was something similar to Figure 2.9.

iii. For both models, only a 'side-to-side', x-coordinate variation is considered. A full model would have to account for 'up-and-down', y-variation; as well as combinations of the two. Identifying these two considerations was adequate for full marks.

Part (c)

Only very few candidates attempted this part. Of those who did, some seemed to have difficulties in modelling the problem, reflecting a lack of understanding of how orthographic projection works.

i. Considering similar triangles where one side is the view line, as per the figure that follows (appreciated but not required by candidates), yields: di=cDist*(VPy/2)/(cSize/2)=2.



ii. Similar considerations for the furthest facet made here, yielding d = (cDist + cSize)*(VPy/2)/(cSize/2) = 6.

iii. No computation necessary here as the vertices will actually lie on the limit of the ViewPort; that is, having coordinates (±VPy/2, ±VPy/2) = (±2, ±2).

iv. Here it is the ViewPort window width (greater than height) that matters; yielding d = (cDist + cSize) * (VPx/2)/(cSize/2) = 10.5.

v. Similar working to (i) yields e = (d * cSize-cubeDist * VPy)/(cSize-VPy) = 3.

An alternative interpretation is to assume the cube remains at z=-8 (instead of maintaining cDist = –8). This gives e = dV * cSize/VPy – cDist = 6. Both approaches were considered correct here.

Question 2

This was the least popular question. However, it attracted the second highest average mark. Parts (a), (b), (c) and (e) are covered in the subject guide and the directed reading; while part (d) involved coding; and part (f) required application of bookwork knowledge to an unseen problem.

Part (a)

This part was bookwork, covered in section 2.1.6 of the subject guide. Paintings like 'Metamorphosis', 'Sky and water', 'Circle III' and 'Relativity' are adequate here. This part was generally well answered.

Part (b)

This is covered in section 2.1.1 (p.29) of the subject guide. What was required to gain full marks here was to present the basic lines of argument; namely: (i) stereo vision conveys sense of depth; (ii) its absence is not that important when modelling distant objects.

This seemed to confuse some candidates.

Part (c)

Related to section 2.2.1 (pp.38–41 of the subject guide). Candidates were expected to sketch an answer illustrating the basic steps of such a process, which would break down to:

1. Take two pictures of the scene/object, with a distance of about 5–7cm from one another (to replicate the distance between the human eyes). There should also be a slight variation in the horizontal angle (pan), which would depend on the distance from the subject.
2. Apply tint (red and cyan) and transparency filters on each image.
3. Superimpose the two images.

The side effect of this approach is that it often results in poor colour or monochrome representation (depending on the colour of the filters used).

Only a few candidates gave an adequate answer here, as most seemed to be quite confused. A mistake that appeared relatively frequently was that of the pictures being taken from the same point, only differing by a slight pan.

Part (d)

Code similar to Figure 2.21 of the subject guide (given below) is required.

```
PImage AshantiLBW = loadImage("AshantiLeftBW.jpg");

PImage AshantiRBW = loadImage("AshantiRightBW.jpg");

int AshantiLwidth = AshantiLBW.width;
```

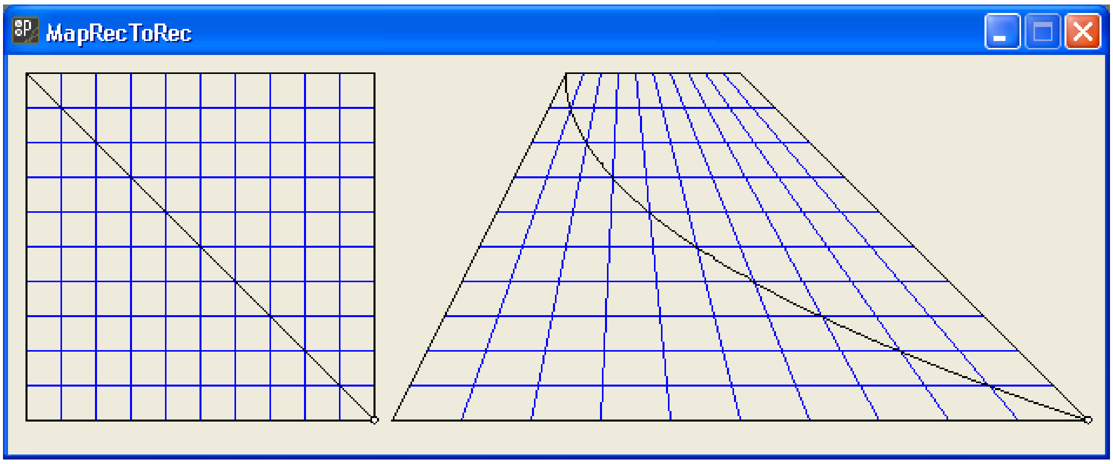
```
int AshantiLheight= AshantiLBW.height;
int scaledHeight = 600;
int scaledWidth  = round(float(scaledHeight)*float(Ashan
tiLwidth)/float(AshantiLheight);
size (scaledWidth,scaledHeight);
tint(255,0,0,255);
image (AshantiLBW,0,0,width,height);//AshantiL.
width,AshantiL.height);
tint(0,255,255,127);
image (AshantiRBW,0,0,width,height);//AshantiL.
width,AshantiL.height);
```

Very few candidates managed to answer this correctly: although images were read properly, the filtering process seemed to confuse candidates. This was natural, as this part was closely related with the previous, thus not understanding the process hindered the implementation.

Part (e)

This is bookwork, covered in section 2.2.3 and specifically p.45 of the subject guide. An indicative answer is:

(i) Shape edges stay straight but: (ii) in general, internal straight line segments in the source shape will map to a curve in the destination shape. This is illustrated in the figure below. The diagonal line in the left hand rectangle maps to the curve in the right hand one. A grid is overlaid on both rectangles at intervals of one tenth the side length. Where opposite sides are not parallel the corresponding grid lines are not parallel either. Note that the mapped diagonal line passes through gridline intersections in both source and destination rectangles.



Candidates appeared to have difficulties with this. Most of those who answered this part were confused with triangle-mapping and attempted to sketch that procedure. However, that was not appropriate here.

Part (f)

i. For example, it can be given as $y-y_1 = m(x-x_1)$, where $m=(y_2-y_1)/(x_2-x_1)$.

ii. Following the previous formulation, $m = 3/2$ and $y_3 = 2$.

iii. The given point is not a solution to the line equation so p_4 is not on the line.

This question involved nothing but basic high-school geometry. Nevertheless, very few candidates attempted to answer it. However, those who did, managed to attract high marks.

Question 3

This was the third most popular question and attracted the lowest average mark. Parts (a) and (d) (i) and (ii) were essentially bookwork; while (b) gave an opportunity for some original observation. Parts (c) (i) and (ii) and (d) (iii) required coding or calculation work, applying what was learned in the CO3343 course.

Part (a)

i. This was bookwork (for example, subject guide section 3.1.1). An example is the mesh/line drawing of a '*mazzocchio*'.

ii. More than one answer is possible here, but a valid one is that artists at that time (for example, Piero della Francesca) had worked out how to map a general point of an object onto the picture plane in perspective. Thus the mesh points, or facet vertices, could be mapped onto the picture and then the painting carried out by interpolating between the points.

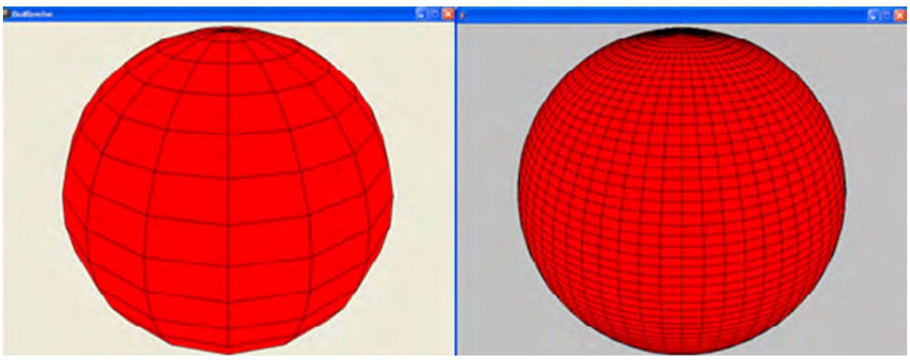
Part (b)

A facetted approximate representation of even a simple curved body, such as a sphere (or a '*mazzocchio*', as in this case) can involve many vertices, lines and facets and so involve a great deal of explicit data description. Furthermore, a faceted representation inherently entails a fixed resolution, contrary to a functional one where 'infinite' magnification can be achieved.

Thus, it makes sense to aim for cases where data can be generated functionally rather than needing explicit calculation and entry for individual vertices.

On the other hand, calculation and modification of a functional representation can be a very computationally intensive task for more complex shapes as often encountered in 3D scenes.

A figure illustrating that in the case of facetted representation and for a smooth appearance of a curved object one has to use very small facet sizes, which can result in substantial extra data being stored. For example, the contrast between Figures 3.11 and 3.12 from the subject guide.



Part (c)

i. What is produced depends on the shape chosen, with marks divided between data, code and drawing; a good attempt at one is able to help make up for deficiencies in another.

   Points to be looked at here were to list the vertex coordinates in proper arrays and to list what vertices make up each facet. The code also needed to show a way of separately recording the multiple instances of any facet or edge with its vertex data, etc. recorded in ACTUAL coordinates.

Code in Figure 3.17 of the subject guide is an example for the case of a cube.

ii. The sketch should be consistent with the previous part. Marks were awarded for correct appearance and orientation.

The vast majority of candidates faced great difficulties answering this part.

Part (d)

i. (See subject guide section 3.2.3, p.66.) The basis of extrusion is to take a planar shape and a projection of it that is not parallel to the plane of the shape.

ii. The core issues to cover were as in the subject guide on this topic (see section 3.2.3), and any explanation could usefully be accompanied by an example sketch. However, any sound explanation that may be based on a wider reading of other texts, would also be acceptable. One approach to explanation could be an elaboration of:

- Start with a 2D (closed loop) of points in SETUP.
- Move in the first instance to start ACTUAL position (can include shaping, such as transforming a circular SETUP set to an ACTUAL oval).
- Then successively transform point data by translation step (not parallel to points plane), possibly transforming points to change shape.
- Then, for each neighbouring pair of points, x1 and x2, in the first loop, moved to x'1 and x'2 in second loop, form two triangular (flat) facets, with consistent vertex ordering when seen from the same side (helps with hidden facet removal process in rendering); for example, (x1, x'1, x2), (x2, x'1, x'2), but another alternative, with (x1,x'2) the repeated edge, is also appropriate, and reverse order appropriate, providing consistency for all pairs of facets.

iii. The result depended on the path chosen. This could be very simple and a sinusoid or another curve or even a straight line would be adequate as long as the description and the illustration were clear and demonstrated understanding.

Very few candidates attempted this part and they had difficulties providing a clear definition and description of the process of extrusion, especially with regards to the orientation of the projection.

Question 4

This was the second most popular question and attracted the third highest average mark, including a few first class answers. Parts (a), (b) (ii), (c) and (d) are essentially bookwork; while part (b)(i) required application of knowledge gained during study in recognition; and (e) derivation of expressions and calculation to solve a previously unseen problem.

Part (a)

This was essentially bookwork, covered on pp.97–98 (section 4.1.2) of the subject guide.

i. The technique that prevailed was lithography. This part was generally well answered.

ii. Japanese woodcut-prints used decorative lines to enclose areas of bright colour. They did not make use of perspective or shadows. This style was incorporated into poster work and also the Japanese method of putting the lips in side profile into a face otherwise in three quarters profile. This part was generally well answered, with candidates identifying the main points.

iii. Appropriate indicative examples are Toulouse Lautrec's 'The Englishman at the *Moulin Rouge*' (Figure 4.3) or '*Divan Japonais*' (Figure 4.4).

Although there were some candidates who gave very adequate answers to this question, not all of them attempted it. There were also some who described Japanese woodcut prints instead; thus, being awarded only a portion of the marks.

Part (b)

i. Image A (on the left) is produced using Gouraud shading; while image B using Phong shading. Gouraud shading interpolates on shade at vertices; while in Phong shading vertex normals are interpolated over a facet, leading to smooth changes of highlight shading even at vertex junctions. Image A shows evidence of this via lines of bright highlight, suggesting it is Gouraud rather than Phong. Such evidence is missing from Image B, which is more smoothly shaded.

The vast majority of candidates correctly identified which shading model was used in each image. However, some did not manage to support their choice with an explanation; or a demonstration of intuition; thus, effectively not gaining full marks.

ii. An indicative answer would be:

For each facet

- for each vertex in the facet
- add vertex normal to vertex normal sum

{end result for each vertex is a total of normal components, therefore weighted by the number of facets of which the vertex is part}

{even the above part is not strictly required, as not yet at the interpolation phase}

The shading works on the basis of scan lines (increasing y and then increasing x on a scanline) for the display device (x,y) pixel coordinates that lie within the projection of the facet onto the screen window.

First, the smallest and largest pixel y values of the projected facet are found (minY and maxY).

For each value of iy (the scan line counter) from minY to maxY:

- {find left and right boundaries of the facet (minX, maxX) in pixel measure, done by:}
- For each edge segment of the facet (defined by two successive vertices)
- if the vertices y values are each side of iy (or only one is equal to iy)
- calculate x-intercept of edge and scanline (xInterp)
- if xInterp is < or > current min or max for facet on scanline
- calculate new (xNMin,yNMin,zNMin) or (xNMax,yNMax,zNMax) respectively
- {now have interpolated normals at each end of scanline segment from facet projection}

- for ix (pixel position) from minX to maxX
- calculate interpolated normal at (ix,iy)
- calculate the shade {matt from angle between normal and light direction;

  specular from angle between reflected ray and view direction using surface colour (for matt), gloss and shine (for specular))}

High marks required demonstration of deep understanding of the algorithm. However, passing marks could be gained based on the general description in the subject guide text. As only the interpolation calculations wanted, the facet normal and Phong shade calculation parts need not be included.

Not many candidates attempted this part and only a small proportion of them managed to gain high marks.

Part (c)

Essentially bookwork, based on section 4.2 of the subject guide. An indicative answer follows:

When white light is incident on a coloured object with a matt surface, then what is reflected is light of the intrinsic colour of that object. When the latter falls, as part of the incident light, on another object of a different intrinsic colour, then the perceived colour of the second object is modified by the set intersection of the two colours.

Only a small proportion of the candidates provided a valid description here.

Part (d)

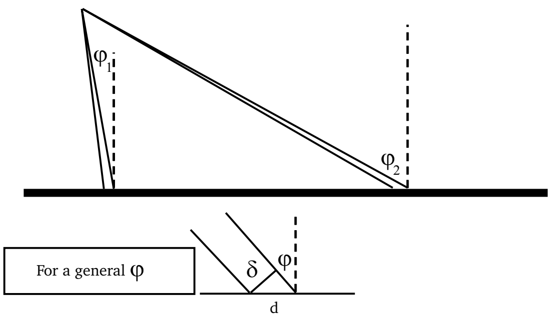
A modification of Figure 4.6 in the subject guide gives a basis for deriving how the intensity variation ($\cos\phi$) at a point, with at least two distinct points on the surface shown to illustrate how intensity varies with incident angle ϕ. That is, consider a narrow (for example, width δ) beam that will be approximately parallel at any point on the facet surface.

Thus, the illumination intensity is $I.\delta/d = I.\delta/(\delta/\cos\phi) = I.\cos\phi$.

When $\phi 1$ becomes small, $\cos\phi 1$ tends to 1.

When $\phi 2$ becomes large (near $\pi/2$), $\cos\phi 2$ tends to 0.

That is, in the diagram, intensity under a near vertical beam, on the left, is greater than for a slanting beam, on the right.



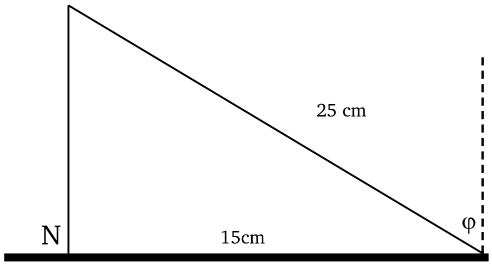
Unfortunately, only a small number of candidates managed to show some intuition and produce the expression correctly.

Part (e)

The illumination intensity is $(I_R, I_G, I_B)\cos\phi$.

The distance of light source from the surface is $\sqrt{(25^2 + 15^2)}$cm = 20cm.

Thus, $\cos\phi = 0.8$ and the reflected colour is $(0,1,0.8) * 0.8 * (I_R,I_G,I_B)$.



Specular reflection on a matt surface is zero, so the reflected colour of P_1 is black (0, 0, 0).

i. Applying the formula derived in (i) yields (0, 0.8, 0.64).

   Most candidates who attempted (i), answered well and consequently did well in (iii), as this was only an application of the former formula. On the other hand, (ii) confused many candidates, despite the fact that it required no calculations whatsoever.

Question 5

Although this question was the least popular choice of candidates, it attracted the highest average mark. Parts (a) and (b) were bookwork; while part (c) required programming; and part (d), application of what is covered in the subject guide and the directed reading; part (d) also required intuition and calculations.

Part (a)

Bookwork, covered in section 6.1.2 of the subject guide (pp.171–72). Any of the example works presented in that section is adequate. This part was generally well answered by candidates.

Part (b)

This is mainly bookwork covered in section 6.2.1 of the subject guide (pp.173–75). An answer showing intuition and covering the main points will gain full marks.

This part was generally well answered.

Part (c)

Indicative code follows:

```
void draw(){
//Producing the trailing effect
//by incompletely clearing the previous image
fill(255,255,255,15);
rect(0,0,width,height);
if(mousePressed){
c = color(random(255), random(255), random(255));
}
fill(c);
ellipse(mouseX,mouseY,radius,radius);
}
```

This was generally well answered. Some indicative mistakes included: omission of comments, no implementation of the trailing effect or other errors such as in random number generation.

Part (d)

i. The histogram of an over(under)-exposed image will generally have a relatively narrow distribution with a peak that is significantly shifted to the right(left). Histogram equalisation flattens the contrast, stretching pixel values to cover the whole dynamic range; that is, somewhat repairing over(under)-exposed images. However, it cannot recover 'lost' pixels resulting from severe over(under)-exposure; namely, 255s or 0s.

   An answer along these lines was expected. Unfortunately, only a few candidates answered well, as most of the answers failed to expose any limitations of the technique.

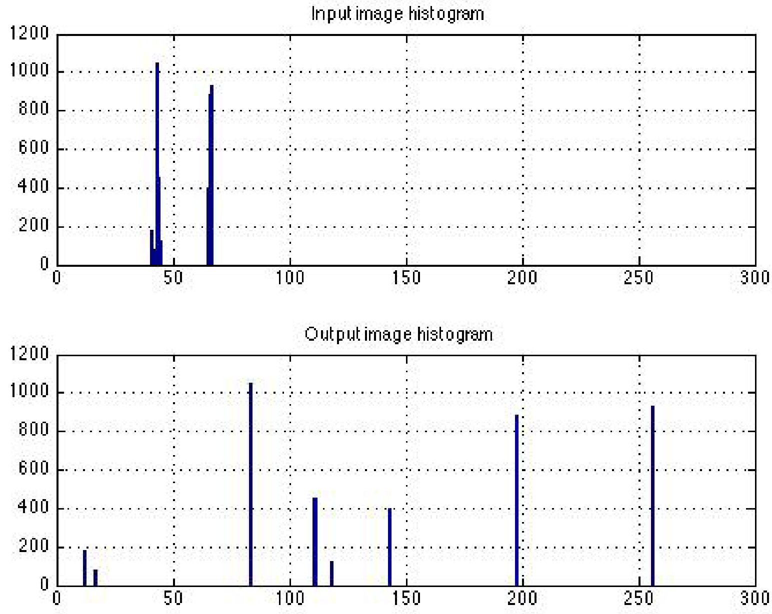
ii. Applying Histogram Equalisation many times will not affect the image (it's an idempotent operation). Unfortunately, only a few candidates realised this.

iii. In extreme cases, the output image can look 'gritty' from having emphasised noise fluctuations present in the original image. Another adverse effect can occur in regions where there are few pixels occurring over a given brightness range, where groups of similar values are combined. This means there is actual information loss, and the original image cannot be recovered.

iv. The following table shows the mapping of grey levels. (Note that some slight differences may be the result of rounding choices):

Grey level value	Mapping
0 to 39	0
40	11
41	16
42	82
43	110
44	117
45 to 63	117
64	142
65	197
66	255
67 to 255	255

The histograms of the input and output images (included for validation – not requested from candidates):



This part was generally well answered. Candidates are reminded that it is always important to show workings in questions of this form so that due credit can be given for a wrong answer due to slips in numerical calculation, but arising from a correct method.