Examiners' reports 2013–14

CO3343 Computing art and image effects – Zone A

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 marks achieved.

Overall, candidates performed satisfactorily, including a number of outstanding submissions that earned first-class marks. On the other hand, there were also some poorer attempts that did not manage to attract a passing mark.

Moreover, it was noticed that some candidates earned high marks in certain questions but performed rather poorly in others. This probably reflects the fact that they had put considerably more effort into certain chapters of the subject guide at the expense of others; resulting in an unbalanced performance.

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.

Comments on specific questions

Question 1

This was the second most popular question but attracted just the fourth highest average mark. Overall, there was a high variance in the quality of the answers with some being exceptionally good, while others unable to achieve a passing score. Parts (a), (b) and (c) are covered in the subject guide and in the directed reading; while part (d) required application of bookwork knowledge to an unseen problem.

Part (a)

The distance between the distance point and the vanishing point should, in theory, correspond exactly to the distance between the viewer's eye and the picture plane. When the distance between the points is small, the viewer must place his or her eye at this same distance from the painting directly in front of the distance point, in order to see the work with no distortion whatsoever. When the viewer stands back from the work, the space in the image will appear distorted. (Subject guide: p.12 and Kemp: pp.342, 343).

While the majority of candidates provided good answers, in a number of cases there was confusion with regard to the definition and the role of vanishing and distance points.

Part (b)

A sample answer could focus on Uccello's 'St. George and the Dragon', both versions of which demonstrate unrealistic effects. (Subject guide pp.6–7, Kemp pp.342–45). Most candidates answered well here.

Part (c)

This was essentially bookwork based on sections 1.2.1 and 2.1.5 of the subject guide. Candidates did generally well in this part.

i. Sample answer on p.6 of the subject guide.

ii. The majority of candidates answered well. Some explained it quite correctly but without mentioning the role of vanishing points or geometry and were awarded 2 out of the 3 marks.

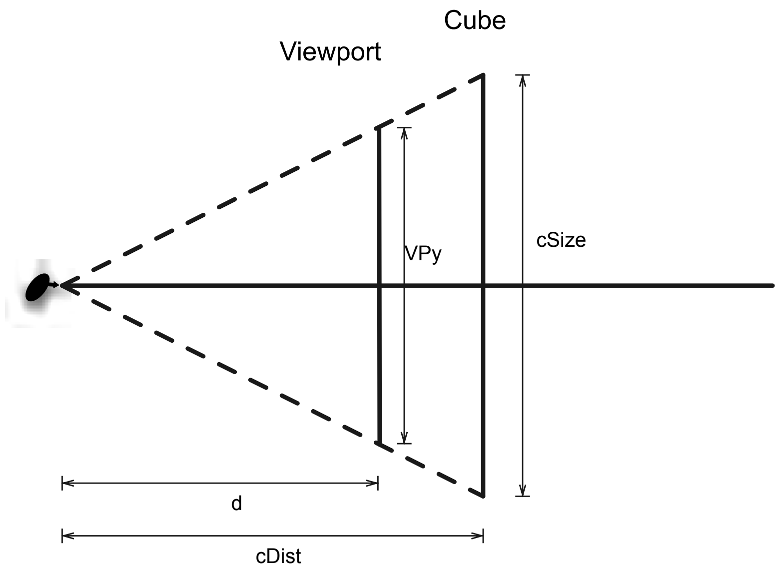
iii. Bi-directional linear and curvilinear perspective were to be mentioned here. See subject guide section 1.2.1, p.16 and section 2.1.5, pp.35–36; while the illustration requested was something similar to Figure 2.9 in the subject guide.

iv. 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 (d)

Most of the candidates seemed to have trouble with the computations required here, despite the fact that they were relatively simple. Problems seemed to stem from a lack of clear understanding of how orthographic projection works, which resulted in difficulties in modelling the problem. However, the vast majority of candidates who managed to approach the problem correctly attracted full marks in this part.

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) = 4

iii. No computation necessary here as the vertices will actually lie on the limit of the ViewPort, i.e. having coordinates (±VPy/2, ±VPy/2) = (±1, ±1)

iv. Here it is the ViewPort window width (greater than height) that matters, yielding d = (cDist + cSize) * (VPx/2)/(cSize/2) = 7

v. Similar working to (i) yields e = (d * cSize – cubeDist * VPy)/(cSize – VPy) = 5.3333. An alternative interpretation was to assume the cube remains at z = –8 (instead of maintaining cDist = –8). This would yield e = dV * cSize/VPy – cDist = 16. Both approaches were considered correct here.

Question 2

This was the fourth most popular question and 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 was bookwork, covered in section 2.1.4 (pp.34–35) of the subject guide. Applicable paintings include '*Les Demoiselles d'Avignon*', 'Girl with a mandolin', '*Ma Jolie*' (Figures 2.5, 2.6 and 2.7 respectively). This 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.

While the first point was generally identified well, some candidates missed the second one.

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 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).

This was generally well answered. 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;
```

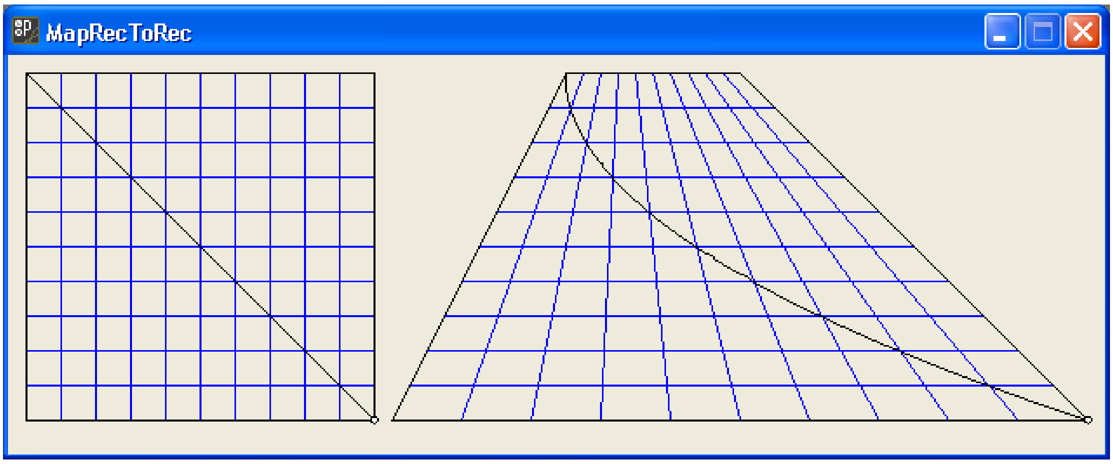
```
int scaledHeight = 600;
int scaledWidth  = round(float(scaledHeight)*float(Ashan
tiLwidth)/float(AshantiLheight));
size (scaledWidth,scaledHeight);
tint(255,0,0,255);
image (AshantiLBW,0,0,width,height);//AshantiL.
width,AshantiL.height);
tint(0,255,255,127);
image (AshantiRBW,0,0,width,height);//AshantiL.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

The vast majority of candidates who answered part (d) well had no problem in providing adequate code for this part.

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 grid line intersections in both source and destination rectangles.



This was generally well answered, although a number of candidates showed some confusion 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 $m = -2/7$ and $y_3 = -3$.

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

This was actually a very simple question, involving only basic high-school geometry. Nevertheless, very few candidates attempted to answer it.

Question 3

This was the least popular question, attempted by only a small proportion of candidates, and earned the lowest average mark. The question seemed to cause candidates difficulties and there were no first-class answers. Parts (a)(i), (ii) and (iii), and (c) (i) and (ii) were essentially bookwork from the subject guide and directed reading, while (a)(iv) gave an opportunity for some original observation. Parts (b) (i) and (ii) and (c) (iii) required coding or calculation work, applying what was learned in the course.

Part (a)

i. Paolo Uccello and Piero della Francesca were among those who created such representations. (SG Section 3.1.1)

ii. Something similar to the Uccello version (as Figure 3.1 in the subject guide), or Piero della Francesca's (Kemp92, Plates 45 and 46) is expected.

iii. A satisfactory answer would include points such as having a vertex edge, of facets, drawing, and so vertices (on a closed sequence of edges) give basic facet description (with explicit edges if required, say for contrasting edge colour), as per the vertex-line-facet description of what information can be stored about a facetted object, for use in the supplied software.

iv. 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 encountered often in 3D scenes.

An answer presenting the basic arguments for each case would gain full marks here.

Most candidates answered parts (i)–(iii) well. Part (iv) seemed to confuse some of them, though there were also some very intuitive answers.

Part (b)

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.

   Although there were generally difficulties in this part, most candidates who chose to work upon a specific example, managed to provide passing answers here. Including in the code information about edge facets, facet colour, etc., although not necessary, helped recover some lost marks.

ii. The sketch should be consistent with the previous part. Marks were for correct appearance and orientation. Candidates seemed to face difficulties with visualising the data that they provided in the previous part.

Part (c)

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.

   Some candidates had problems providing a clear definition here, especially with regards to the orientation of the projection.

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.

   Only a few candidates attempted this part and, despite a number of very good answers, most had difficulties describing the process.

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.

   The quality of the answers provided here was analogous to the ones given in the previous part.

Question 4

This was the most popular question but attracted only the third highest average mark. 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 in pages 95–96 (section 4.1.1) of the subject guide.

i. The term is '*chiaroscuro*' or 'play of light'.

   The vast majority of candidates answered correctly.

ii. Indicative appropriate examples are Rembrandt's 'The prophetess Anna' (Figure 4.1) or 'A Girl leaning on a stone pedestal' (Figure 4.2).

   Most of the answers were good and gained high marks. A very important point was to focus in the use of light and its effects.

Part (b)

i. Image A (on the left) was produced using constant shading, while image B using Phong shading. Constant shading gives same shade across the whole facet while in Phong shading vertex normals are interpolated over a facet, leading to smooth changes of highlight shading even at vertex junctions.

The vast majority of candidates had no problem in identifying this and gained full marks.

ii. A sample 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 needed not be included.

Only a few managed to gain full marks in this part. While there were some very good attempts that showed intuition and described the solution verbally and some with explanatory figures, most of them did not expose the computational details.

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.

Most of the answers mentioned that the colour of the second surface will be affected by the colour of the first one, but not all of them adequately explained how (set intersection of colour components).

Part (d)

A modification of Figure 4.6 in the subject guide gives a basis for deriving how the intensity variation (cos ϕ) at a point, with at least two distinct points on the surface shown to illustrate how intensity varies with incident angle ϕ.

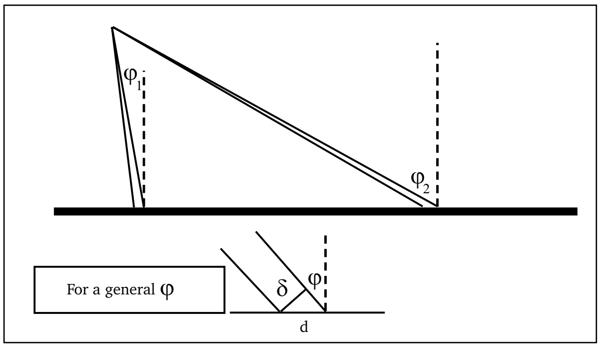
I.e. consider a narrow (e.g. width δ) beam that will be approximately parallel at any point on the facet surface.

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

When ϕ_1 becomes small, $\cos\phi_1$ tends to 1.

When ϕ_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, greater than for a slanting beam, on the right.



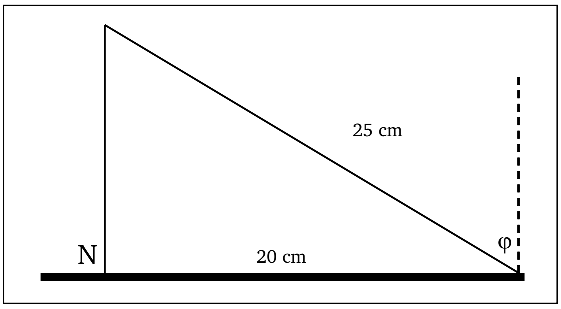
This was not very well answered. A high proportion of candidates did provide the correct expression but did not show how it was derived. Merely providing the expression is not enough; you need to show some intuition and understanding of what its variables represent. Also, some of the submissions did not contain illustrations.

Part (e)

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

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

   Thus, $\cos\phi = 0.6$ and the reflected colour is $(1,0.5,0)*0.6*(I_R,I_G,I_B)$.



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

iii. Applying the formula derived in (i) yields (0.6, 0.3, 0).

Most of the candidates who attempted (i), answered well and consequently did well in (iii), as this was only an application of the previous formula.

On the other hand, (ii) confused many candidates, despite the fact that it required no calculations whatsoever.

Question 5

Although this question was only the third most popular choice of the 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, example works in subject guide pp.175–76, 'The city rises' (Figure 6.9) and 'Unique forms of continuity in space' (Figure 6.10). This was generally well answered.

Part (b)

Bookwork, subject guide pp.177–78. Appropriate points include: angularity of scenery, figures in out-of-proportion spaces (e.g. clerks on high stools in low-ceiling rooms in *The Cabinet of Dr Caligari*), buildings depicted as flat/diagrammatic, multi-perspectives causing anxiety with curves and slanting lines (for example, radial patterns in the floor; prison cell with 'verticals' converging as they rise, to emphasise height and sense of oppression, and lines continued across the floor to the prisoner (all in *The Cabinet of Dr Caligari*); use of shadow instead of figure (over the bed of the traveller, and ascending stairs), use of figure rising from prone to vertical as though hinged at heels (in *Nosferatu*).

Comments about how structural unfamiliarity or impossibility run counter to expectations of the everyday, and so cause discomfort, also are appropriate. Most candidates answered this well.

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: the 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; i.e., somewhat repairing over(under)-exposed images. However, it cannot recover 'lost' pixels resulting from severe over(under)-exposure; that is, 255s or 0s.

   An answer along these lines was expected. However, only a few candidates answered well. Most of the answers only described the virtues of the method, not exposing limitations.

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

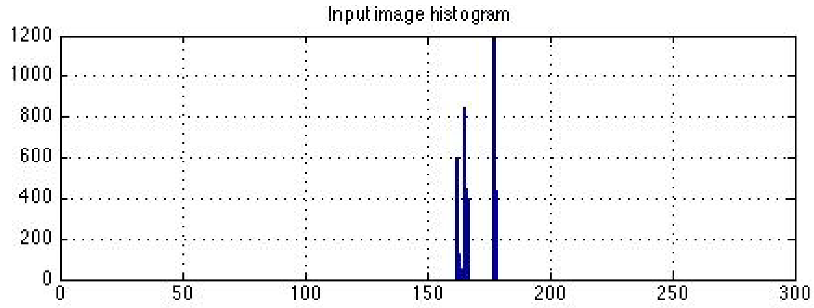
iii. In extreme cases the output image can look 'gritty' from having emphasised noise fluctuations present in the original image. Another adverse effect can occur in regions where there are few pixels occurring over a given brightness range, where groups of similar values are combined. This means there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

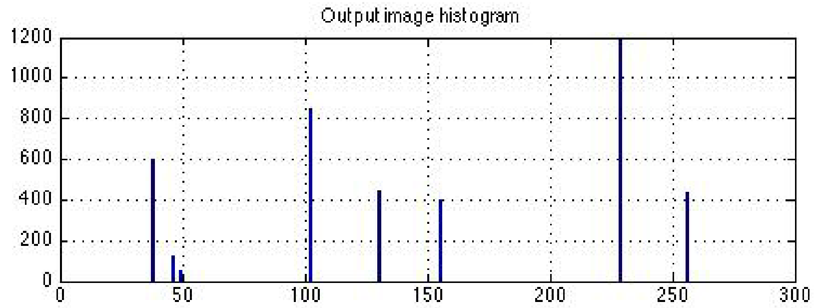
   This was generally well-answered.

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 160	0
161	37
162	45
163	48
164	101
165	129
166	154
167 to 175	154
176	228
177	255
178 to 255	255

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





The majority of the candidates who attempted this, managed to do very well and attract full marks. A portion of the marks was awarded to candidates who only calculated the running sums.