CompSci 373 S1 C 2012
Computer Graphics and Image Processing

Mid Term Test – Tuesday, 3rd May 2012, 6.30 pm – 7.30 pm

VERSION CODE 00000001

Instructions:

1. Enter your *name*, *student ID* and the *version number* shown on the top left into the teleform sheet supplied. Your name should be entered left aligned. If you have a middle initial, enter it under MI. If your name is longer than the number of boxes provided, truncate it.
2. Use a dark pencil to mark your answers on the teleform sheet supplied. If you spoil your sheet, ask the exam supervisor for a replacement. Writing on this question book will **NOT be marked**.
3. If you want to change your answer **erase the previously filled in box completely** using an eraser.
4. All questions must be answered in the multiple choice answer boxes on the teleform sheet corresponding to the respective question number. There is only one correct answer for each question.
5. **Questions total 50 Marks**. Each question is worth 2 marks.
6. Attempt **ALL** questions.
7. The test is for 60 minutes.
8. This is a **closed book** test.
9. Calculators and electronic devices are **NOT** permitted.
10. This test is worth 20% of your final marks for CompSci373 S1 C

Question 1:

The dot product of $\mathbf{u} = \begin{pmatrix} 1 \\ -2 \\ 3 \end{pmatrix}$ and $\mathbf{v} = \begin{pmatrix} 1 \\ 2 \\ 1 \end{pmatrix}$ equals

    (a) -1
    (b) 0
    (c) 8
    (d) 12
    (e) None of the others

Comment [BCW1]: Correct

Question 2:

The cross product of $\mathbf{u} = \begin{pmatrix} 1 \\ -2 \\ 3 \end{pmatrix}$ and $\mathbf{v} = \begin{pmatrix} 1 \\ 2 \\ 1 \end{pmatrix}$ equals

    (a) 0

    (b) $\begin{pmatrix} -8 \\ -2 \\ 4 \end{pmatrix}$

    (c) $\begin{pmatrix} 4 \\ 2 \\ -8 \end{pmatrix}$

    (d) $\begin{pmatrix} -8 \\ 2 \\ 4 \end{pmatrix}$

Comment [BCW2]: Correct

    (e) None of the others

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Question 3:

The orthogonal projection of vector $\mathbf{b} = \begin{pmatrix} -1 \\ -\sqrt{2} \\ 3\sqrt{2} \end{pmatrix}$ onto vector $\mathbf{a} = \begin{pmatrix} 0 \\ \sqrt{2} \\ \sqrt{2} \end{pmatrix}$ is equal to

(a) $2\begin{pmatrix} 0 \\ \sqrt{2} \\ \sqrt{2} \end{pmatrix}$

(b) 2

(c) $\begin{pmatrix} 0 \\ -2 \\ 6 \end{pmatrix}$

(d) $\begin{pmatrix} -1 \\ -\sqrt{2} \\ 3\sqrt{2} \end{pmatrix}$

(e) None of the others

> **Comment [BCW3]:** Correct (0, sqrt(2), sqrt(2))

Question 4:

What is the equation of the plan containing the points p=$\begin{pmatrix} 1 \\ 0 \\ -1 \end{pmatrix}$, q=$\begin{pmatrix} 0 \\ -1 \\ 1 \end{pmatrix}$ and r=$\begin{pmatrix} -1 \\ 0 \\ 1 \end{pmatrix}$?

(a) x+y+z=1
(b) x+y+z=0
(c) 2x+y+z=1
(d) 3x+2y+z=2
(e) None of the others

> **Comment [BCW4]:** Correct

Question 5:

The distance from point $\mathbf{p}=\begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}$ to the plane defined by the equation $x + y + z = 1$ is equal to:

(a) 2

(b) $\dfrac{2}{\sqrt{3}}$

(c) 0 (point $\mathbf{p}$ is on the plane)

(d) $3 - \sqrt{3}$

(e) None of the others

> **Comment [BCW5]:** Correct

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Question 6:

What is the distance between the plane defined by equation $x - y + z = -\sqrt{3}$ and the origin:

    (a) $\sqrt{3}$
    (b) 0 (the origin is on the plane)
    (c) 1   `Comment [BCW6]: Correct`
    (d) 3
    (e) None of the others

Question 7:

What are the coordinates of the 2D Cartesian point $\mathbf{p} = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$ after performing the following

transformations: first a shearing with the parameter sx=sy=2; then a rotation of 45 degrees; then scaling with the parameters sx=0, sy=1 and finally a translation with the parameters tx=2, ty=1:

`Comment [BCW7]: Correct`

    (a) $\begin{pmatrix} 2 \\ 3\sqrt{2} + 1 \end{pmatrix}$

    (b) $\begin{pmatrix} 0 \\ 1 \end{pmatrix}$

    (c) $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$

    (d) $\begin{pmatrix} \sqrt{2} \\ \sqrt{2} \end{pmatrix}$

    (e) None of the others

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Question 8:

An object has a local coordinate system $\mathbf{a}=(1,0,0)$, $\mathbf{b}=(0,1,0)$, $\mathbf{c}=(0,0,1)$ with origin $(3,2,1)$. Which homogeneous matrix rotates the object into a new coordinate system $\mathbf{u}=(0,0,1)$, $\mathbf{v}=(0,-1,0)$, $\mathbf{n}=(1,0,0)$ with the same origin as before?

(a) $\begin{pmatrix} 1 & 0 & 1 & 3 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

(b) $\begin{pmatrix} 0 & 0 & 1 & 3 \\ 0 & -1 & 0 & 2 \\ 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

(c) $\begin{pmatrix} 0 & 0 & 1 & 2 \\ 0 & -1 & 0 & 4 \\ 1 & 0 & 0 & -2 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

Comment [BCW8]: Correct

(d) $\begin{pmatrix} 1 & 0 & 1 & 2 \\ 0 & 1 & 0 & 4 \\ 0 & 0 & 1 & -2 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

(e) None of the others

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Question 9:
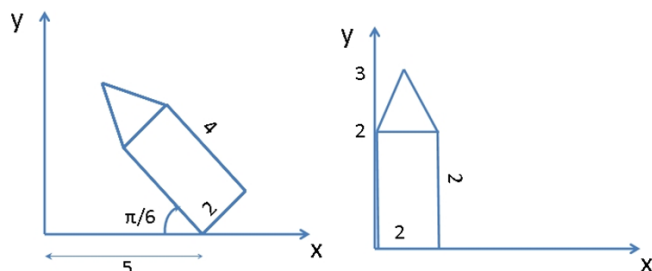
Which homogeneous 2D matrix transforms the figure on the left side to the figure on the right?
Please note that $\cos(\pi/6) = \sqrt{3}/2$ and $\sin(\pi/6) = 1/2$.

(a) $\begin{pmatrix} 1/2 & -\sqrt{3} & 5 \\ \sqrt{3}/2 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$

(b) $\begin{pmatrix} 1/2 & \sqrt{3}/2 & -5/2 \\ -\sqrt{3}/4 & 1/4 & 5\sqrt{3}/4 \\ 0 & 0 & 1 \end{pmatrix}$

Comment [BCW9]: Correct

(c) $\begin{pmatrix} 1/2 & \sqrt{3}/2 & -5/2 \\ -\sqrt{3}/2 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$

(d) $\begin{pmatrix} 1 & 3 & -5 \\ -\sqrt{3}/2 & 1/2 & 0 \\ 0 & 0 & 1 \end{pmatrix}$

(e) None of the others

Question 10:

Assume **u** and **v** are 3 by 1 vectors, and **I** is the 3 by 3 identity matrix.
Which of the following statements, if any, is *false*?

(a) The cross product of **u** by **v** and of **v** by **u** produce two vectors of opposite direction i.e.
   u×v = -v×u
(b) The magnitude of the cross product of **u** by **v** is equal to the area of the parallelogram
   defined by the vectors **u** and **v**
(c) The cross product of **u** and **v** creates a vector which is orthogonal to both vector **u** and **v**
(d) The magnitude of the cross product of **u** and **v** is always equal to the product of the
   magnitudes of vector **u** and **v**
(e) None of the other statements is false

Comment [BCW10]: Correct

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Question 11:

Which of the following statements on Phong illumination is *true*?

(a) Diffuse reflection is dependent on the viewing angle
(b) If you want to make the highlight on a surface larger, you have to increase the intensity of the diffuse light
(c) Ambient reflection depends on the angle between the light source and the surface normal
(d) The specular reflection is influenced by the reflection direction and the angle at the reflection point between the light and viewing direction
(e) None of the others

Comment [BCW11]: Correct

Question 12:

Which of the following statements on shading is *true*?

(a) "Mach bands" is an optical illusion which makes intensity transition between adjacent shaded regions look higher than they actually are. It appears when using Flat and Gouraud shading techniques.
(b) Gouraud shading interpolates surface normals on the polygon and then computes the Phong equation for all surface pixels
(c) Flat shading only computes the Phong illumination on surface vertices
(d) Phong shading computes the Phong equation on all vertices and then computes colors for pixels between vertices using bilinear interpolation
(e) None of the others

Comment [BCW12]: Correct

Question 13:

What is the intersection point $p(t_0)$ of the ray $p(t) = \begin{pmatrix} 0 \\ 1 \\ -1 \end{pmatrix} + t \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}$ with the plane given by the equation x+y+z=1?

(a) The intersection point is $\mathbf{p}(t_0)$ where $t_0 = 0$
(b) The intersection point is $\mathbf{p}(t_0)$ where $t_0 = \dfrac{1}{3}$
(c) The intersection point is $\mathbf{p}(t_0)$ where $t_0 = 1$
(d) The intersection point is $\mathbf{p}(t_0)$ where $t_0 = \sqrt{2}$
(e) None of the others

Comment [BCW13]: Correct

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Question 14:

Which of the statements below is *true*?

    (a) GLU is the main function library for polygon rendering
    (b) GLU is the OpenGL Utility library
    (c) GLU is the OpenGL Utility Toolkit
    (d) GLU provides support for a windowing environment in a window-system independent
        manner
    (e) None of the above

Comment [BCW14]: Correct

Question 15:

Given is an OpenGL program rendering two squares. One square occupies only a few pixels on the screen, whereas the other square occupies half the screen space. Which of the following statements is *true*?

    (a) Performing the MODELVIEW and PROJECTION transformation takes longer for the
        larger square.
    (b) Performing the illumination calculation takes longer for the larger square.
    (c) Performing the viewport transformation takes longer for the larger square.
    (d) Performing the rasterization step takes longer for the larger square.
    (e) The statements (a) – (d) are all false

Comment [BCW15]: Correct

Question 16:

Given is the following code drawing a line segment:

```
glBegin(GL_LINES);
glColor3f(1.0, 0.0, 1.0);
glVertex3f(0.0, 1.0, 1.0);
glColor3f(0.0, 0.3, 0.7);
glVertex3f(1.0, 0.0, 0.0);
glEnd();
```

What is the colour of the line segment at the point (2/3, 1/3, 1/3)?

    (a) (2/3, 0.1, 0.9)
    (b) (1/3, 0.2, 0.8)
    (c) (2/3, 1/3, 2/3)
    (d) (1/3, 0.1, 0.9)
    (e) None of the others

Comment [b16]: Correct

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Question 17:

In the lecture we learned that gluOrtho2D is implementing a world-to-viewport mapping. Given is a world window with the left bottom corner (0, 0) and the top-right corner (200, 100). What is the homogeneous matrix mapping this world window into a window on the screen (viewport), which is aligned with the top-left corner of the screen and has a width of 200 pixels and height of 100 pixels?

TIP: Make yourself an illustration. Keep in mind the different positions of the world and screen coordinate system. You can solve this question either by using the formula derived in the lecture, or easier, by just thinking about the meaning of the different components of the world-to-viewport mapping.

(a) $\begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & -100 \\ 0 & 0 & 1 \end{pmatrix}$

(b) $\begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 100 \\ 0 & 0 & 1 \end{pmatrix}$

Comment [BCW17]: Correct

(c) $\begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & 100 \\ 0 & 0 & 1 \end{pmatrix}$

(d) $\begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 200 \\ 0 & 0 & 1 \end{pmatrix}$

(e) $\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 200 \\ 0 & 0 & 1 \end{pmatrix}$

Question 18:

A cube is drawn using two quadrilaterals (GL_QUADS) for its top and bottom face and one quadstrip (GL_QUAD_STRIP) for the front, left, back and right face. What is the minimum number of glVertex calls necessary to draw a cube in this way?
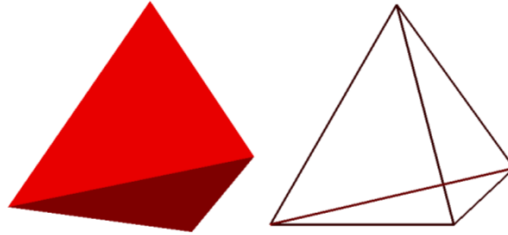
(a) 12
(b) 14
(c) 18
(d) 20
(e) 24

Comment [BCW18]: Correct

Question 19:

Given are the 3D vertices

```
CVec3df v[4];
v[0].setVector(0.0, 0.0, 0.0);
v[1].setVector(1.0, 0.0, 0.0);
v[2].setVector(0.5, 1.0, 0.0);
v[3].setVector(0.5, 0.5, 1.0);
```

We want to draw a tetrahedral shape as indicated in the picture on the right (using flat shading and a wireframe representation). Which calling sequence of these vertices (using `glVertex3fv`) defines such as tetrahedral shape if we use the OpenGL commands `glBegin(GL_TRIANGLE_STRIP)` and `glEnd()`?
You can assume that the normals for each triangle of the resulting shape are correctly defined. Note that you do not need to know which corner of the shape in the image corresponds to which vertex – only one calling sequence results in for correct triangles forming the shape.

(a) 0, 1, 2, 3
(b) 0, 3, 2, 1
(c) 0, 1, 2, 3, 2, 1
(d) 0, 3, 2, 1, 3, 1
(e) 0, 2, 1, 3, 0, 2

Comment [BCW19]: Correct

Question 20:

Given are the vertices

```
const int numVertices=10;
const float vertices[numVertices][2] =
   {{100,50},{150,50},{250,50},{300,50},
    {150,150},{200,100},{250,150},{150,300},
    {250,300},{200,400}};
```

Which calling sequence of these vertices (using `glVertex2fv`) results in the shape on the right if we use the OpenGL commands `glBegin(GL_TRIANGLE_FAN)` and `glEnd()`?
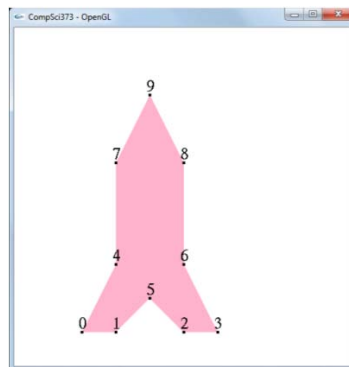
(a) 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
(b) 9, 8, 6, 3, 2, 5, 1, 0, 4, 7
(c) 0, 4, 7, 9, 8, 6, 3, 2, 5, 1
(d) 5, 1, 0, 4, 7, 9, 8, 6, 3, 2
(e) None of the above
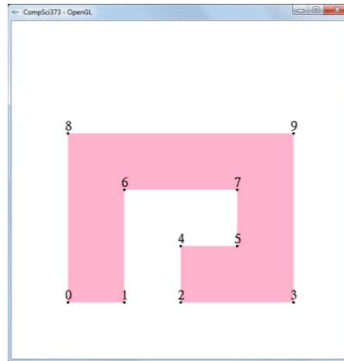
Comment [BCW20]: Correct

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Question 21:

Given are the vertices

```
const int numVertices=10;
const float vertices[numVertices][2] =
   {{100,100},{200,100},{300,100},{500,100},
    {300,200},{400,200},{200,300},{400,300},
    {100,400},{500,400}};
```

Which calling sequence of these vertices (using `glVertex2fv`) results in the shape on the right if we use the OpenGL commands `glBegin(`**`GL_QUAD_STRIP`**`)` and `glEnd()`?

    (a) 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
    (b) 0, 1, 8, 6, 7, 9, 5, 3, 4, 2
    (c) 0, 8, 1, 6, 2, 4, 5, 7, 3, 9
    (d) 0, 1, 8, 6, 9, 7, 3, 5, 2, 4
    (e) None of the above

Comment [BCW21]: Correct

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Question 22:

Which modelview matrix is generated by the following code segment?

```
glMatrixMode(GL_MODELVIEW);
glLoadIdentity();
glTranslatef(1, 0, 2);
glRotatef(φ, 0, 1, 0);
glScalef(1, 2, 1);
```

(a) $\begin{pmatrix} \cos\varphi & 0 & \sin\varphi & 1 \\ 0 & 2 & 0 & 0 \\ -\sin\varphi & 0 & \cos\varphi & 2 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

Comment [BCW22]: Correct

(b) $\begin{pmatrix} \cos\varphi & 0 & -\sin\varphi & 1 \\ 0 & 2 & 0 & 0 \\ \sin\varphi & 0 & \cos\varphi & 2 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

(c) $\begin{pmatrix} \cos\varphi & 0 & \sin\varphi & \cos\varphi + 2\sin\varphi \\ 0 & 2 & 0 & 0 \\ -\sin\varphi & 0 & \cos\varphi & -\sin\varphi + 2\cos\varphi \\ 0 & 0 & 0 & 1 \end{pmatrix}$

(d) $\begin{pmatrix} \cos\varphi & 0 & -\sin\varphi & \cos\varphi - 2\sin\varphi \\ 0 & 2 & 0 & 0 \\ \sin\varphi & 0 & \cos\varphi & \sin\varphi + 2\cos\varphi \\ 0 & 0 & 0 & 1 \end{pmatrix}$

(e) None of the above

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Question 23:

Given is the scene on the right. It consists
of a cube centred at the origin with a side
length of 2 units. Inserted into the front face
and right hand side face of the cube is a
torus with an inner radius of 0.2 units and
an outer radius of 0.8 units such that exactly
half of each torus lies outside the cube.
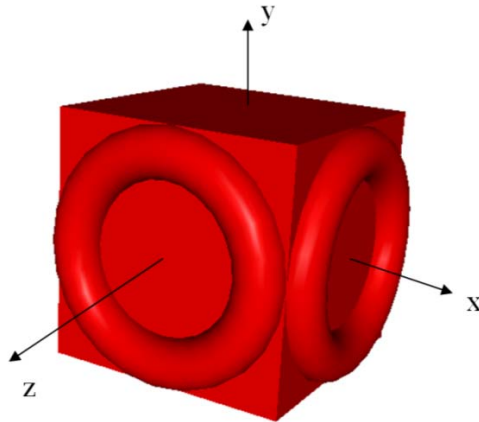
Assume the following functions are given:

```
void myCube();
```

draws a cube centred at the origin with a side length of 2.

```
void myTorus();
```

draws a torus centred at the origin with an inner radius of 0.2, an outer radius of 0.8 and its axis
aligned with the z-axis.

Which of the code segments below draws the scene described above?

(a) myCube();
    glPushMatrix();
    glTranslatef(1,0,0);
    myTorus();
    glPopMatrix();
    glTranslatef(0,0,1);
    glRotatef(90,0,1,0);
    myTorus();

(b) myCube();
    glTranslatef(0,0,1);
    myTorus();
   glRotatef(90,0,1,0);
    glTranslatef(1,0,0);
    myTorus();

(c) myCube();
    glPushMatrix();
    glTranslatef(0,0,1);
    myTorus();
    glPopMatrix();
    glTranslatef(1,0,0);
    glRotatef(90,0,1,0);
    myTorus();

Comment [BCW23]: Correct

(d) myCube();
    glTranslatef(1,0,0);
    myTorus();
    glRotatef(90,0,1,0);
    glTranslatef(0,0,1);
    myTorus();

(e) None of the above

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Question 24:

Given is a function *drawTriangle()* which draws a wire frame triangle in the xy-plane as shown in the image below on the left. Which code segment displays the transformed shape in the picture below on the right?
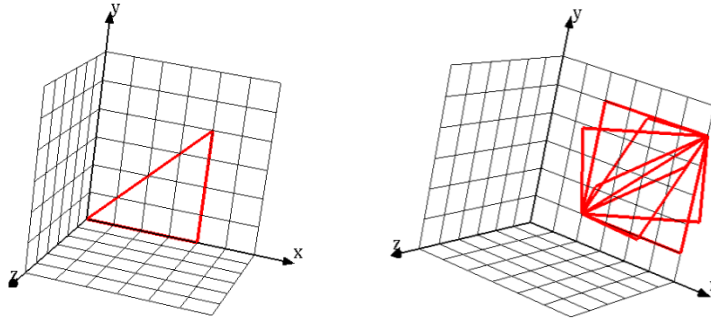
(a) for(int i=0;i<8;i++){
         glPushMatrix();
         glRotatef(360.0*i/8.0, 2, 1, 0);
         glTranslatef(1, 1, 0);
         drawTriangle();
         glPopMatrix();
     }

(b) for(int i=0;i<8;i++){
         glPushMatrix();
         glRotatef(360.0*i/8.0, 1, 1, 0);
         glTranslatef(2, 1, 0);
         drawTriangle();
         glPopMatrix();
     }

(c) for(int i=0;i<8;i++){
         glPushMatrix();
         glTranslatef(1, 1, 0);
         glRotatef(360.0*i/8.0, 2, 1, 0);
         drawTriangle();
         glPopMatrix();
     }

(d) for(int i=0;i<8;i++){
         glPushMatrix();
         glTranslatef(2, 1, 0);
         glRotatef(360.0*i/8.0, 1, 1, 0);
         drawTriangle();
         glPopMatrix();
     }

Comment [BCW24]: Correct
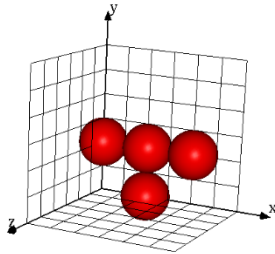
(e) None of the above
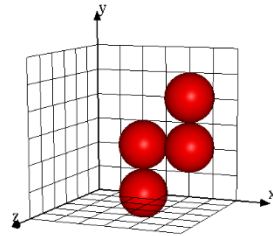
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Question 25:

What image is drawn by the following code segment?

```
glTranslatef(2.0, 0.0, 0.0);
glutSolidSphere(1.0, 32, 32);
glPushMatrix();
glTranslatef(2.0, 2.0, 0.0);
glutSolidSphere(1.0, 32, 32);
glPopMatrix();
glTranslatef(-2.0, 0.0, 0.0);
glutSolidSphere(1.0, 32, 32);
glTranslatef(0.0, 2.0, 0.0);
glutSolidSphere(1.0, 32, 32);
glPopMatrix();
```
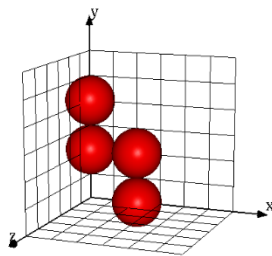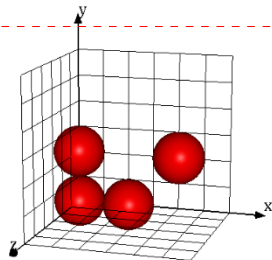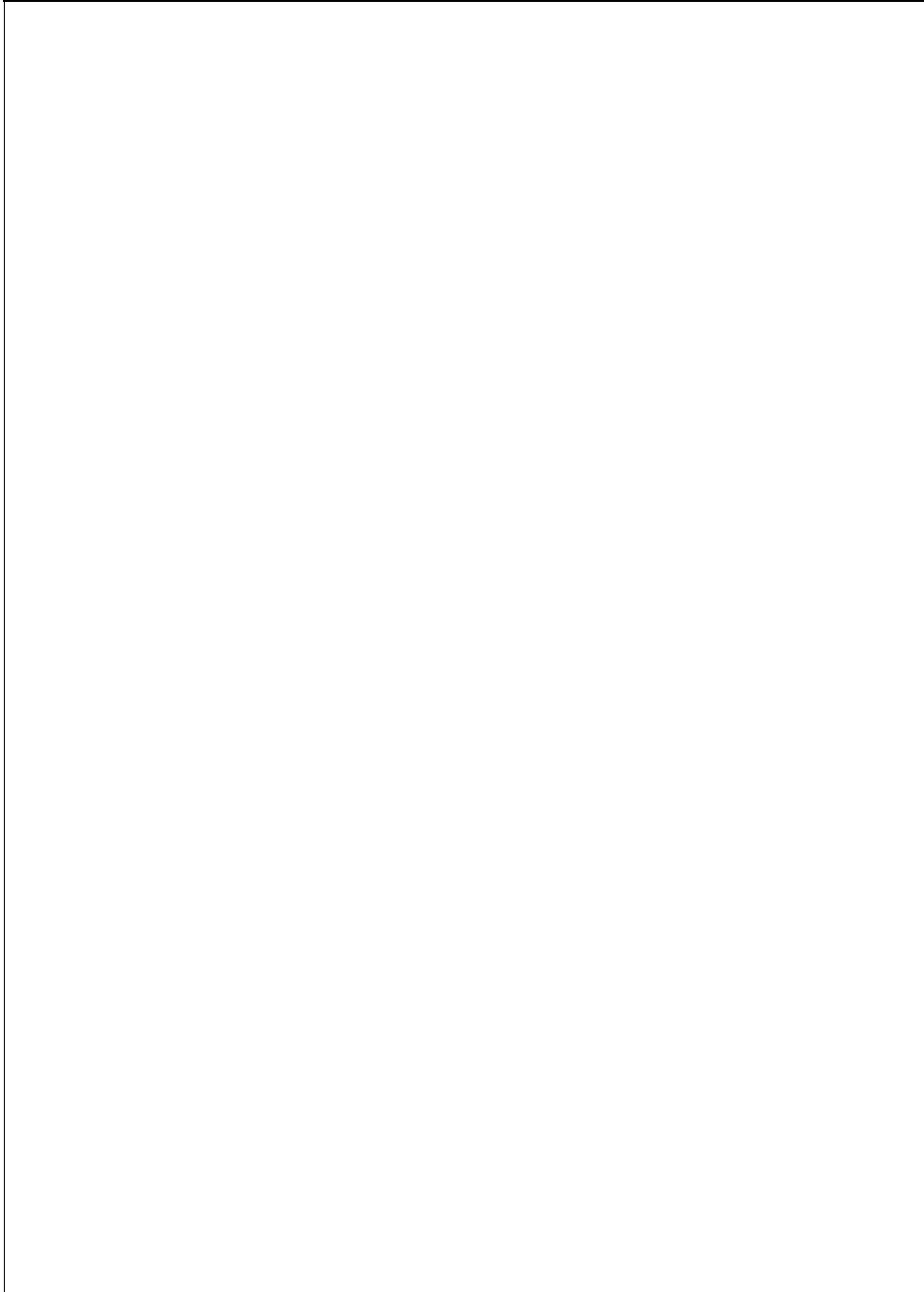
(a)

(d)

(b)

(e)   None of the above

(c)

Comment [BCW25]: Correct

Rough Working – This page will not be marked