Student Number:	
Name:	
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The University of Melbourne

Mid Semester Test 2013 - Sample solutions

Department of Computing and Information Systems
COMP30019 Graphics and Interaction

Reading Time	5 Minutes
Writing Time	40 Minutes during the Lecture
Writing Time	Handing back paper (5 minutes)

This paper has 6 pages including this cover page.

Identical Examination Papers:	None.
Common Content Papers:	None.

Authorised Materials:
Open Book: Any materials are allowed into the Mid Semester Test

Instructions:
Students must write all of their answers on this examination paper. Students may not remove any part of the examination paper from the lecture.

Instructions to Students:
This mid semester test counts for 5% of your final grade, however student are expected to attempt the test **ANSWER ALL** questions in the indicated answer boxes on THE PAPER PROVIDED IN THE LECTURE. Only material written inside the boxes will be marked. If you need to make rough notes, or prepare draft answers, you may do so on the reverse of any page.

Paper to be held by Baillieu Library: No.

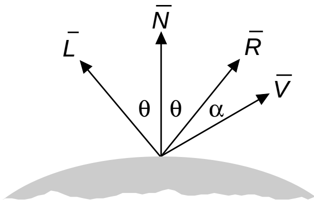
Examiners use only:

Q1:	Q2:

Question 1 **(2.5 Marks)**

A form of the Phong illumination model is shown below, in terms of an equation and a diagram that shows how angles, θ and α, from the equation relate to the (normalised) vectors $\bar{L}$ for the light source, $\bar{N}$ for the objects surface normal, $\bar{R}$ for the direction of reflection and $\bar{V}$ for the viewpoint direction.

$$I_\lambda = I_{x\lambda} k_x O_{y\lambda} + f_{att} I_{t\lambda}[k_y O_{y\lambda} cos\theta + k_z cos^n \alpha]$$



(a). Write down an expression for the intensity of *ambient reflection*, in the direction of the viewpoint $\bar{V}$, using terms from the equation above.

Solution:

$$I_{x\lambda} k_x O_{y\lambda}$$

(b). Write down an expression for the intensity of *Lambertian reflection*, in the direction of the viewpoint $\bar{V}$, using terms from the equation above.

Solution:

$$f_{att} I_{t\lambda} k_y O_{y\lambda} cos\theta$$

(c). Write down an expression for the intensity of *Specular reflection*, in the direction of the viewpoint $\bar{V}$, using terms from the equation above.

Solution:

$$f_{att} I_{t\lambda} k_z cos^n \alpha$$

0.5 mark (half mark for incorrect (a), (b) or (c)

(d). Implementing the Phong illumination model using the equation in the form shown above is computationally expensive. Write down a new form of the equation above that reduces the computation cost of evaluation. State (in one sentence) why your new equation is more efficient.

Solution:

$$I_\lambda = I_{x\lambda} k_x O_{y\lambda} + f_{att} I_{t\lambda} [k_y O_{y\lambda} (\bar{N}.\bar{L}) + k_s (\bar{R}.\bar{V})^n]$$

Replacing trigonometric functions with vectors is more efficient, since computing dot products is significantly faster than computing trigonometric functions.

0.5 mark

(e). Explain how *Lambertian reflection* is related to the distance of the viewer from the surface. Be sure to explain why this is the case.

Solution:

Independence of distance of viewer from surface:

As the surface moves further away from the viewer, the received light intensity falls off as an inverse-square law in distance.

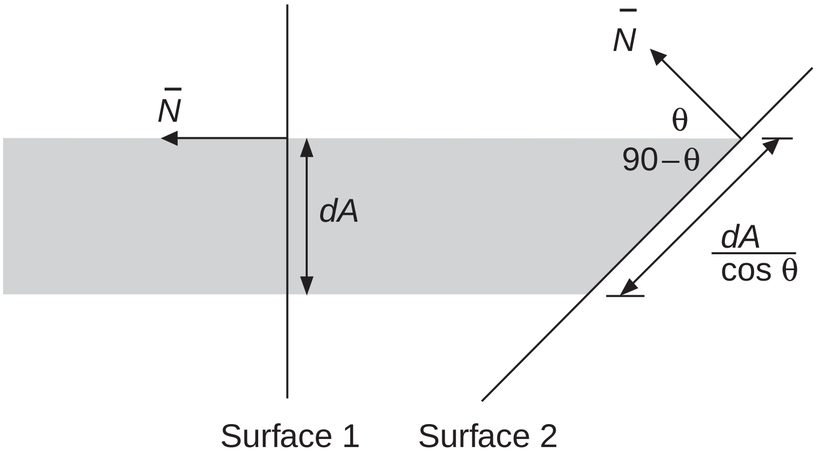
However, for a given angle subtended at the viewer, the amount of surface included grows in proportion to the square of the distance.

These two effects *compensate*, so that intensity of Lambertian reflection is independent of the distance of the surface from the viewer.

0.5 marks

(f). Draw a diagram in the box below that explains how *Lambertian reflection* is related to the orientation of the viewer, $\bar{V}$ in the figure, and how it depends on angles θ and/or α. Be sure to explain why.

Solution:



Independence of surface orientation:

For a given small surface patch, the amount of light radiated towards the viewer is greatest when the surface normal is pointing straight at the viewer, and falls off according to a cosine law as the surface slants away from the viewer, according to θ.

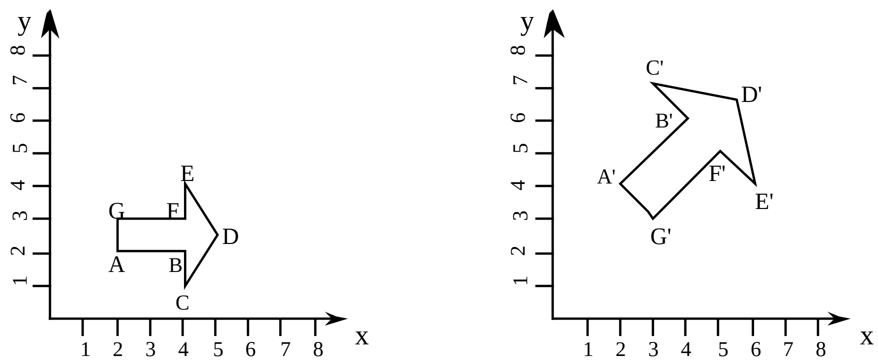
However, at the same time, for a given visual angle subtended at the viewer, more of the surface is seen within that angle as the surface slants away from the viewer, again according to a cosine law.

These two effects exactly compensate, so, overall, Lambertian reflection is independent of surface orientation with respect to the viewer.

1 mark

Question 2 **(2.5 Marks)**

This question concerns transformation geometry and matrices. The figure below shows the transformation of an object ABCDEFG (on the left) into new position A'B'C'D'E'F'G' (on the right).
The (x, y) coordinates of the points of the object on the left are: A $(2, 2)$, B $(4, 2)$, C $(4, 1)$, D $(5, 2.5)$, E $(4, 4)$, F $(4, 3)$ and G $(2, 3)$.
The coordinates of the points for the object as shown on the right are: A' $(2, 4)$, B' $(4, 6)$, C' $(3, 7)$, D' $(5.5, 6.5)$, E' $(6, 4)$, F' $(5, 5)$, and G' $(3, 3)$.



(a). Write down, in words, a sequence of transformations that transforms object ABCDEFG into the object A'B'C'D'E'F'G', as shown above. For example, an incorrect sequence would be *"rotation 90 degrees clockwise; translation 10 in x dimension and -5 in y dimension; etc."*.

Solution:

(i). Translate A to origin (-2 in x and -2 in y).

(ii). Scale reflect about the x axis (1 in x and -1 in y).

(iii). Scale $\sqrt{2}$ in x and $\sqrt{2}$ in y.

(iv). Rotate by $\theta = 45$ degrees (anti-clockwise).

(v). Translate to A' (2 in x and 4 in y).

1 marks (half mark off per incorrect translation, scaling and rotation; Note: there are many ways of legally achieving this, so need to think about alternative answers; however, students should realise there is shorted (simpler) transformation sequence if they give really complicated one) (b). Write down *each* of the transformation matrices named in your answer to the question about the sequence of transformations (subquestion (a)), in homogeneous form, together with their numerical factors. Be sure to identify the transformations by name.

Solution:

Translate A to origin

$$\mathbf{T_1} = \begin{bmatrix} 1 & & -2 \\ & 1 & -2 \\ & & 1 \end{bmatrix}$$

Scale. Use AB and $A^{'}B^{'}$ to determine scale in x and AG and $A^{'}G^{'}$ to determine scale in y.

$$S_x = \frac{\sqrt{2^2+2^2}}{2^2+0^2} = \sqrt{2}$$

$$S_y = \frac{\sqrt{1^2+1^2}}{0^2+1^2} = \sqrt{2}$$

Scale. Reflect about the x axis.

$$S_x = 1$$

$$S_y = -1$$

$$\mathbf{T_4} = \begin{bmatrix} 1 & & \\ & -1 & \\ & & 1 \end{bmatrix}$$

Rotate by $\theta = 45\,\text{deg}$

$$\mathbf{T_2} = \begin{bmatrix} cos(\theta) & -sin(\theta) & \\ sin(\theta) & cos(\theta) & \\ & & 1 \end{bmatrix} = \begin{bmatrix} 1/\sqrt{2} & -1/\sqrt{2} & \\ 1/\sqrt{2} & 1/\sqrt{2} & \\ & & 1 \end{bmatrix}$$

Translate to A'.

$$\mathbf{T_5} = \begin{bmatrix} 1 & & 2 \\ & 1 & 4 \\ & & 1 \end{bmatrix}$$

1.5 marks (correct translation, scaling and rotation matrices)