topics:

- transformations
- camera
- visual effects: lighting, shading, materials
- texture mapping

references:

- http://www.evl.uic.edu/spiff/class/cs426/, by Prof Jason Leigh, University of Illinois at Chicago (http://www.evl.uic.edu/spiff/) and Prof Robert Kooima, Louisiana State University (http://csc.lsu.edu/~kooima/)

transformations

- there are 3 types of transformations:
  - translation (called “grab” in blender) — move object along x, y or z axes
  - scale — change size of object along x, y or z axes
  - rotation — rotate object about x, y or z axes
- origin of object for transformation matters
- order of transformations matters, if the transformations are performed within the local coordinate system of the object

example: translate, then rotate

```
start
translate y+ = 1
then rotate x+ = 10
```

example: rotate, then translate

```
start
rotate x+ = 10
then translate y+ = 1
```

camera

- not only is position of camera important, but also the planes that define what it sees
- the near clipping plane defines the closest objects the camera can see
- the far clipping plane defines the furthest objects the camera can see
- the view volume is the 3D volume bounded by the near and far clipping planes that define the volume that the camera can see
- the projection plane defines how the 3D view volume is projected onto a 2D region for displaying on a computer screen
- illustration on next page:
lighting

- there are different types of light:
  - ambient—evenly illuminates all objects in scene
  - directional—all light rays are parallel (i.e., in the same direction)
  - point—all light rays emanate from one point
  - spot—all light rays emanate from one point and radiate out in a cone shape

- reflection:
  - diffuse
    * the greater the angle between the vector normal (perpendicular) to the surface and a vector to the light source, the less light is reflected
    * most light is reflected at $0^\circ$
    * no light is reflected at $90^\circ$
  - specular
    * maximum specular reflectance occurs when viewpoint is along path of perfectly reflected ray

- lighting effects in blender:
  - color of ambient light in the world
  - ambient occlusion
  - effect of ambient light on object’s material
  - indirect lighting (color that another object radiates onto object of concern)
  - lamps

- lighting settings:
  - type of light
  - color
  - position and direction
  - other settings include energy level and falloff (attenuation)
    * attenuation can be linear or quadratic or mixed

- how light is reflected on diffuse vs specular surfaces:
  - diffuse
    - Lamp
    - Incident Light Ray
    - Normal
    - Reflection
    - Hardness
  - specular
    - Lamp
    - Incident Light Ray
    - Normal
    - Reflection
    - Hardness
shading

- shading defines how light behaves when it hits the surface of an object
- various methods are used to interpolate value of shadow
  - Gouraud shading: interpolate intensity of light along edges of polygon
  - Phong shading: interpolate normals

- Lambert diffuse shaders (in blender):

- Toon diffuse shader (in blender):

- various parameter settings for Toon shader, for example (in blender):
materials properties in blender

• diffuse shaders
  – defines color of material when light hits it
  – shadows controlled by falloff settings
  – color/shading are independent of viewpoint

• specular shaders
  – defines bright highlights of glossy materials
  – specular reflection defined by Snell’s Law, which basically says that light will be
    reflected with regard to the surface normal, based on the incident angle of the light
    source
  – color/shading are dependent on viewpoint
  – note that specular reflection is not mirroring (which is achieved in blender using
    raytracing)

• ambient light effect
  – defines the amount of ambient light that hits an object
  – can be modulated using environment lighting (e.g., lamp property settings) and
    ambient occlusion (i.e., object(s) blocking the light, placed between the light source
    and the object of concern)

• color ramps
  – defines range of color that is blended in when object is in shadow
  – controls color gradient
  – takes precedence over textures in blender

• raytraced reflection
  – defines “mirror effect”
  – light ray emanates from camera and bounces off nearest object—depending on
    transparency settings: opaque objects cause light to bounce off with the same color
    settings as the original light; transparent objects cause light to go through the object
    with a modulated color, depending on the color of the transparent object and the
    amount of transparency
  – note that, in blender, raytracing needs to be turned on in the scene properties

• raytraced transparency
  – defines refraction of light rays when they travel through transparent objects
  – as above, transparent objects cause light to go through the object with a modulated
    color, depending on the color of the transparent object and the amount of transparency
  – index of refraction for object’s material defines how light is reflected

• subsurface scattering
  – some materials (e.g., human skin) have “layers”, so reflection properties are essentially
    a combination of the properties of each layer, modulated according to which layer is on
    the “top” (closest to light source)

• strands
  – defines how hair is rendered in blender
  – based on multiple polygons, which can be rendered in different ways
  – refer to blender manual for details

• volume materials
  – defines rendering method for when light passes through an object
  – two types: solid rendering (e.g., solid object) and volume rendering (e.g., cloud, mist)
texture mapping

• use images (e.g., jpg, gif) of textures and wrap these on the faces of objects in blender
• the UV editor in blender handles this
  – a 3D object is defined in x-y-z space
  – a 2D face is defined in u-v space (where u refers to up/down; and v refers to left/right)
• a good source for textures is:
  http://www.mayang.com/textures
• how to map a texture to a surface in blender:
  – select object whose face you want to map with a texture
  – go into object Edit Mode
  – click on “U” and then “Unwrap” and the “Face select” button to be able to select one face
  – right-click the face to edit
  – select UV/Image editor panel (on properties panel)
  – select “Image” - “Open image” and select an image file (e.g., jpg) to map to selected object face

– back in the 3D view window, set the viewport shading mode to “Textured”
– now you should see the texture-mapped face
• modify texture:
  – you can use the object manipulation controls to change the scale and shape of the texture map
  – for example, make the texture map small in order for it to repeat on the object surface
  – or make it big to zoom it on the object surface
  – or modify vertices of texture map to distort it on the object surface