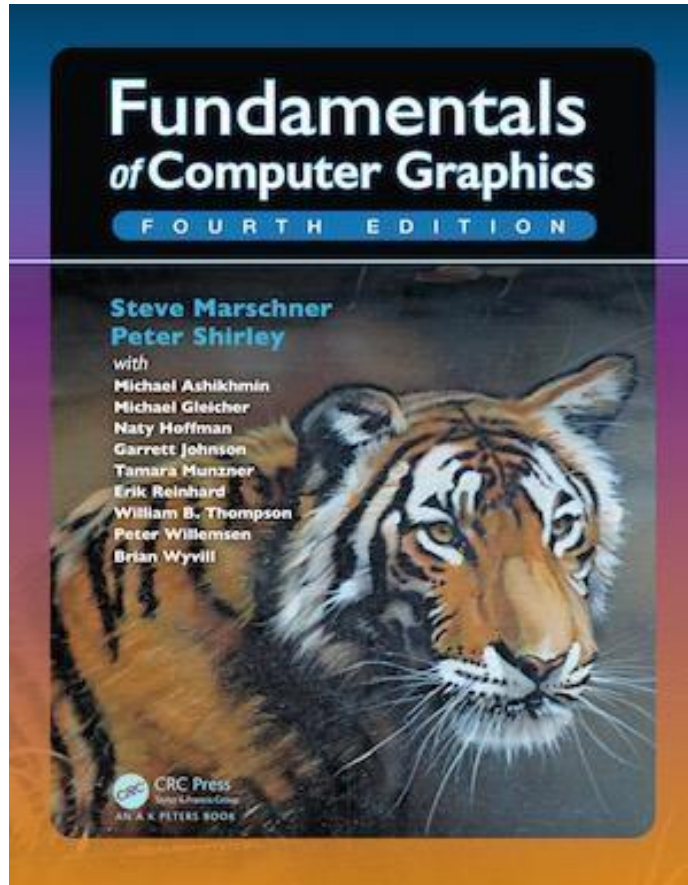


CSE4203: Computer Graphics  
Chapter – 4 (part - A)  
**Ray Tracing**

# Outline

- Projection
- Parallel projection
- Perspective projection
- Vanishing point

# Credit



## CS4620: Introduction to Computer Graphics

Cornell University

Instructor: Steve Marschner

<http://www.cs.cornell.edu/courses/cs4620/2019fa/>

# 3D → 2D

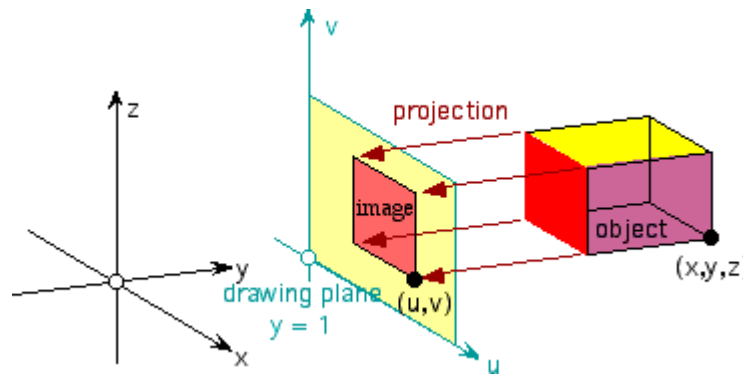
```
12221_Cat_v1_l3.obj x
10 v 0.6134 -21.9357 31.4441
11 v 0.6205 -21.8541 31.4935
12 v 0.5534 -21.8682 31.5159
13 v 0.5464 -21.9516 31.4643
14 v 0.6207 -21.7610 31.5371
15 v 0.5544 -21.7724 31.5613
16 v 0.4816 -21.8847 31.5310
17 v 0.4743 -21.9703 31.4781
18 v 0.4838 -21.7858 31.5776
19 v 0.6156 -21.6618 31.5749
20 v 0.6070 -21.5619 31.6064
21 v 0.5439 -21.5675 31.6330
22 v 0.5507 -21.6702 31.6005
23 v 0.4772 -21.5744 31.6514
24 v 0.4819 -21.6802 31.6178
25 v 0.3320 -21.5913 31.6699
26 v 0.3330 -21.7025 31.6343
27 v 0.4094 -21.6911 31.6286
28 v 0.4067 -21.5824 31.6631
29 v 0.3317 -21.8143 31.5926
30 v 0.4094 -21.8001 31.5875
31 v 0.3275 -21.9189 31.5447
```



3D model Source: <https://free3d.com>  
Model viewer: <http://masc.cs.gmu.edu/wiki/ObjViewer>

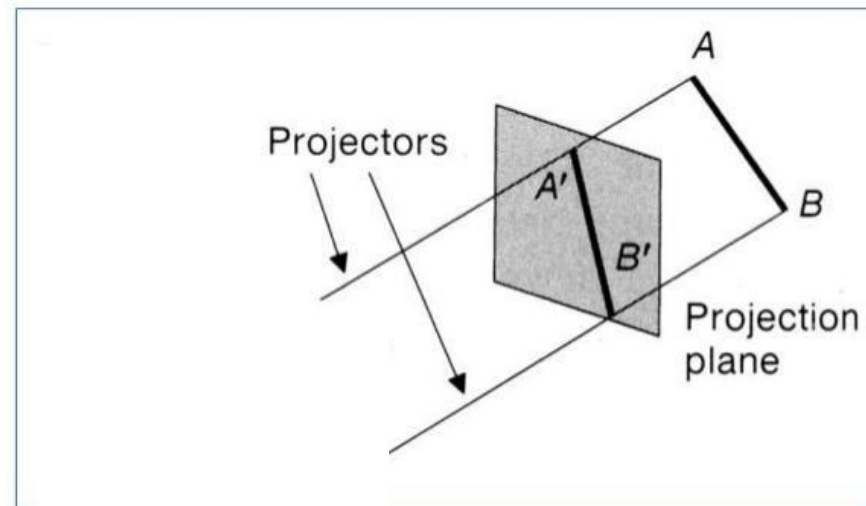
# Projection (1/2)

- Representing a 3D object
  - Photographs also represent 3D scenes with 2D images.
- In computer graphics, **Projection** is used.



# Projection (2/2)

- 3D points are mapped to 2D image plane by moving them along a *projection direction*
  - *until they hit the image plane*

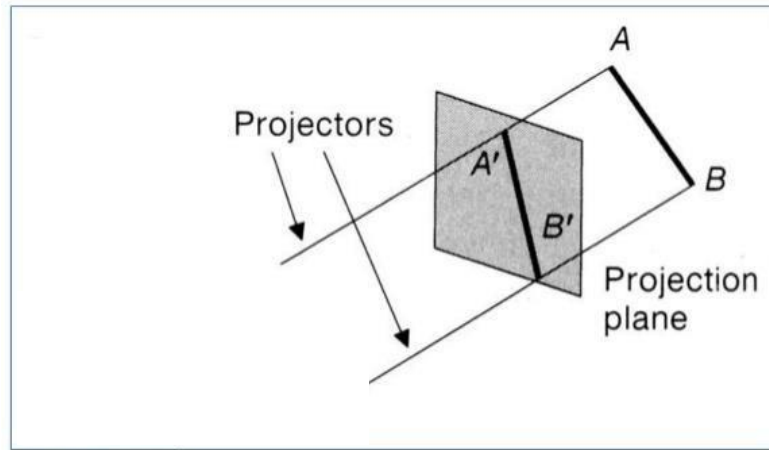


Credit: Fundamentals of Computer Graphics 4<sup>th</sup> Edition by Peter Shirley, Steve Marschner | <http://www.cs.cornell.edu/courses/cs4620/2019fa/>

# Types of Projection (1/1)

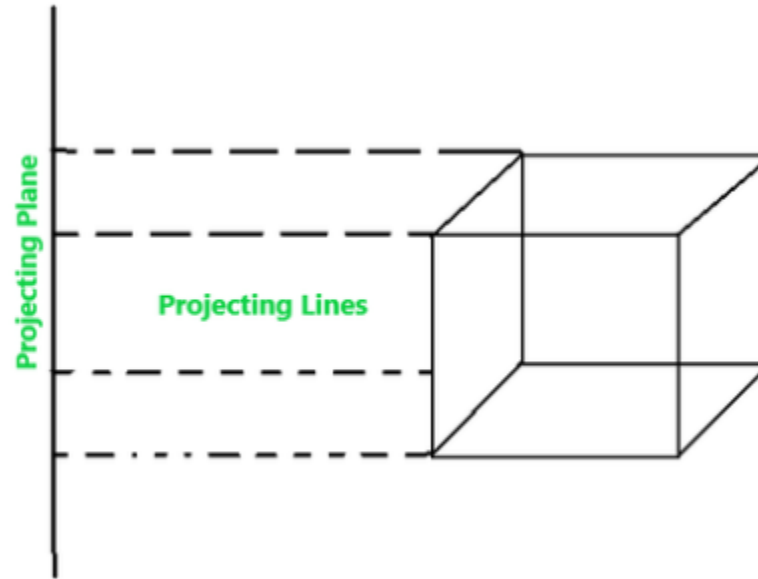
Main types:

- Parallel
- Perspective



# Parallel Projection (1/3)

- Projectors are parallel
  - Center of Projection (CoP) lies at infinity

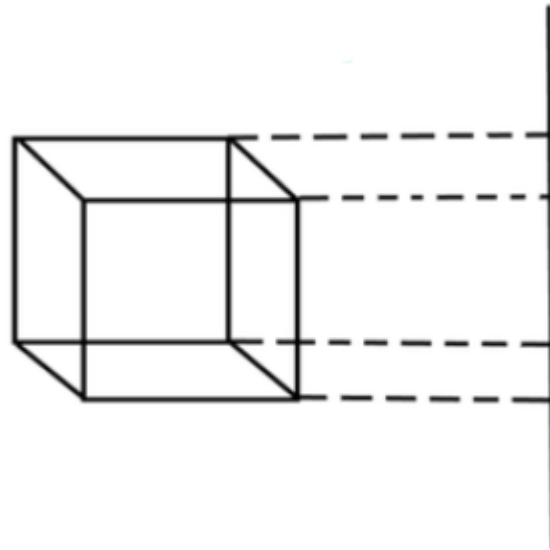


Credit: Fundamentals of Computer Graphics 4<sup>th</sup> Edition by Peter Shirley, Steve Marschner | <http://www.cs.cornell.edu/courses/cs4620/2019fa/>  
Image: <https://www.geeksforgeeks.org/parallel-orthographic-oblique-projection-in-computer-graphics/?ref=rp>



# Parallel Projection (2/3)

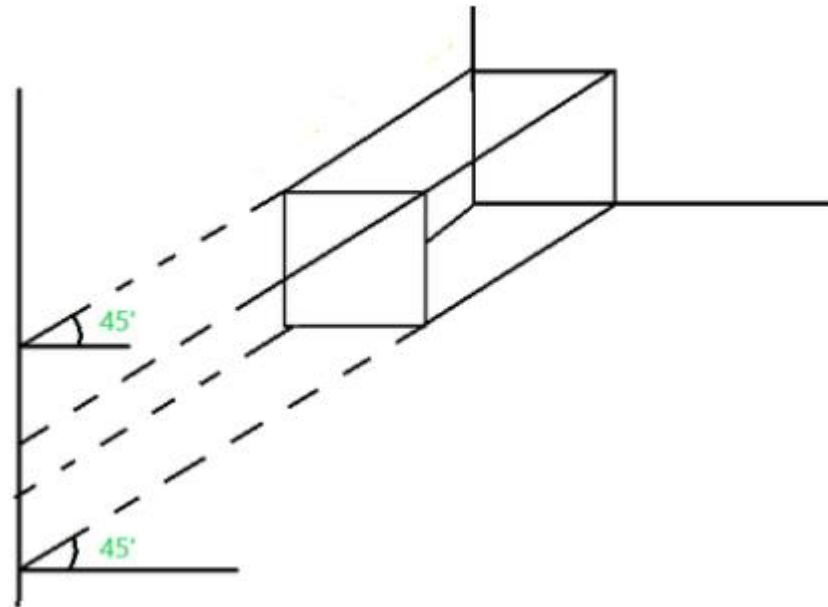
- Orthographic
  - Image plane  $\perp$  projector



Credit: Fundamentals of Computer Graphics 4<sup>th</sup> Edition by Peter Shirley, Steve Marschner | <http://www.cs.cornell.edu/courses/cs4620/2019fa/>

# Parallel Projection (3/3)

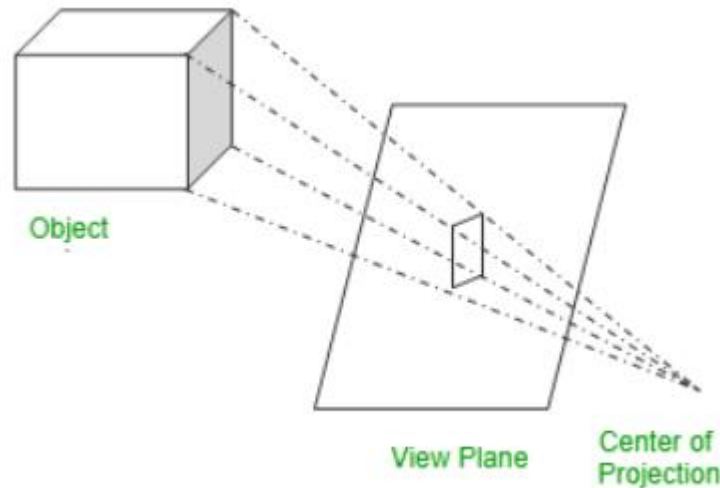
- Oblique
  - Image plane  $\nparallel$  projector



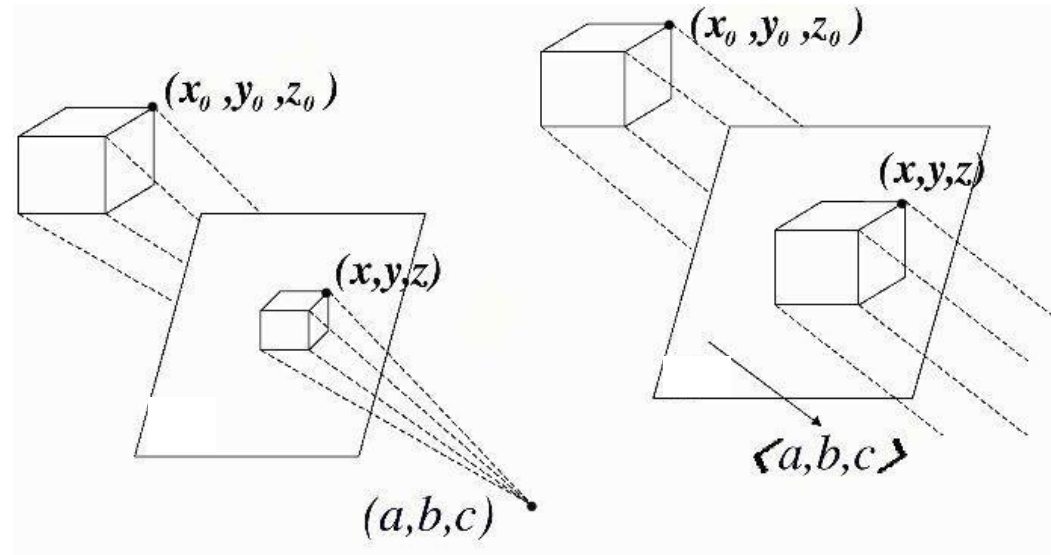
Credit: Fundamentals of Computer Graphics 4<sup>th</sup> Edition by Peter Shirley, Steve Marschner | <http://www.cs.cornell.edu/courses/cs4620/2019fa/>

# Perspective Projection (1/2)

- Projectors do not remain parallel
- Projectors meet at a point finite point



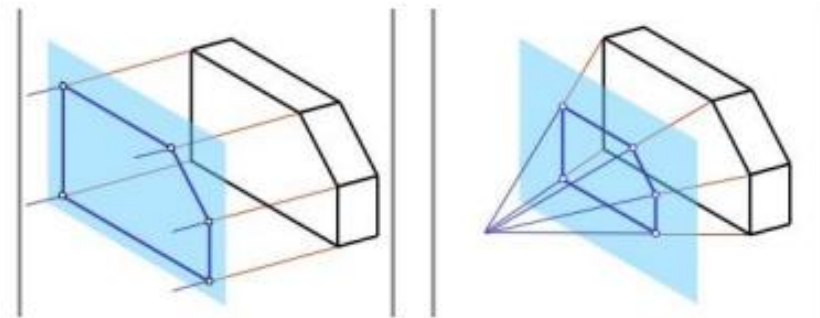
# Perspective Projection (2/2)



- Does parallel project have a CP?
  - What will happen if the object moves near/ far?
- Play around:  
[http://www.cs.cornell.edu/courses/cs4620/2017sp/demos/view\\_explore/view\\_explore.html](http://www.cs.cornell.edu/courses/cs4620/2017sp/demos/view_explore/view_explore.html)

# Parallel vs Perspective (1/2)

- Parallel projections are often used for mechanical and architectural drawings because they keep parallel lines parallel
  - preserve the size and shape of planar objects that are parallel to the image plane



Credit: Fundamentals of Computer Graphics 4<sup>th</sup> Edition by Peter Shirley, Steve Marschner | <http://www.cs.cornell.edu/courses/cs4620/2019fa/>

# Parallel vs Perspective (2/2)

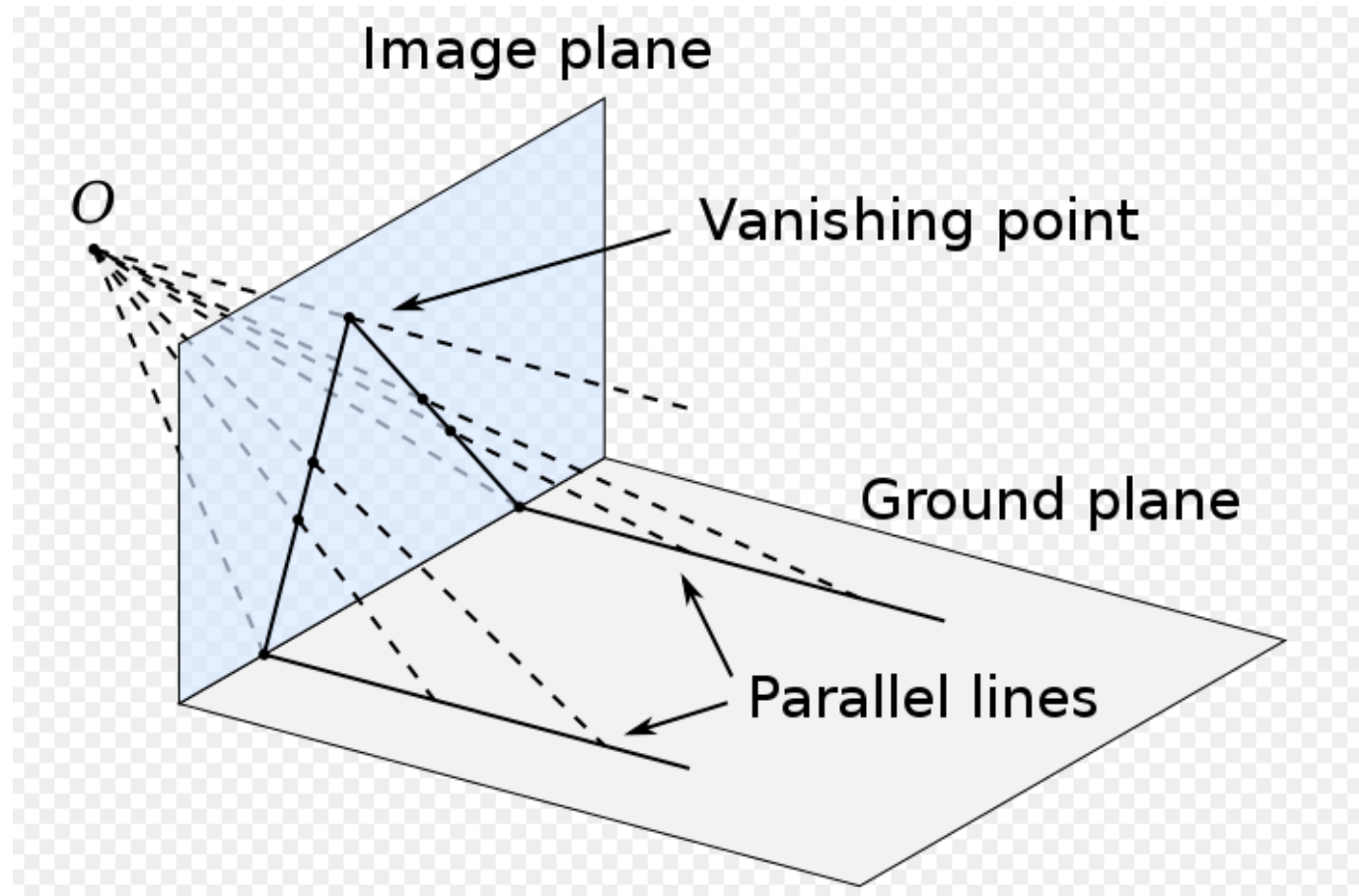
- In our everyday experience (and in photographs)
  - objects look smaller  $\leftrightarrow$  farther away



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# Vanishing Point (1/2)

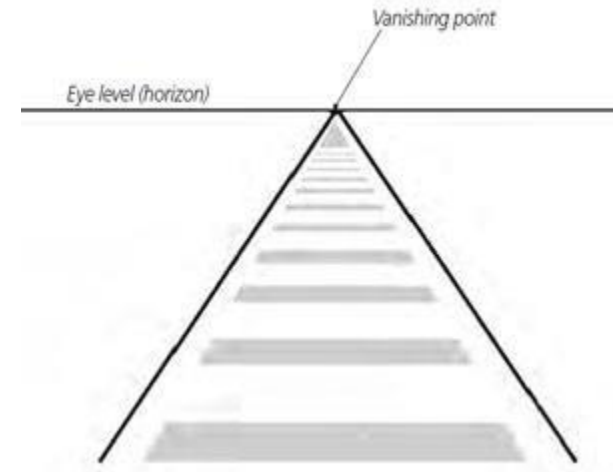
Q: Where is the VP here?



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# Vanishing Point (2/2)

- Vanishing points:
  - Any set of parallel lines that are not parallel to the projection plane will converge to a vanishing point.
  - Parallel horizontal lines meet at a point on the horizon.
  - Every set of parallel lines has own VP



**Q: Which type of parallel lines does not meet at VP?**

Image source: <https://www.artistsnetwork.com/art-terms/vanishing-point-perspective/>

Credit: Fundamentals of Computer Graphics 4<sup>th</sup> Edition by Peter Shirley, Steve Marschner | <http://www.cs.cornell.edu/courses/cs4620/2019fa/>



# Perspective Projection (Examples)

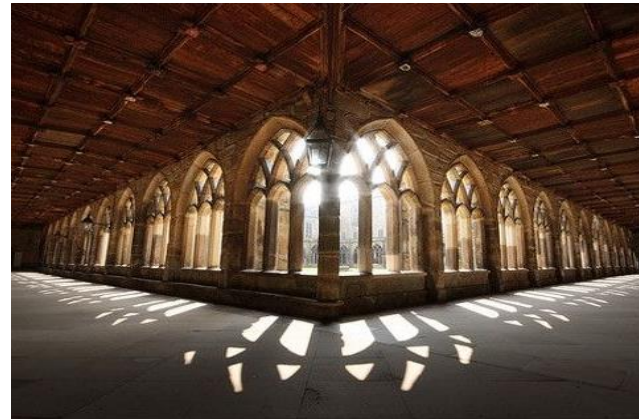
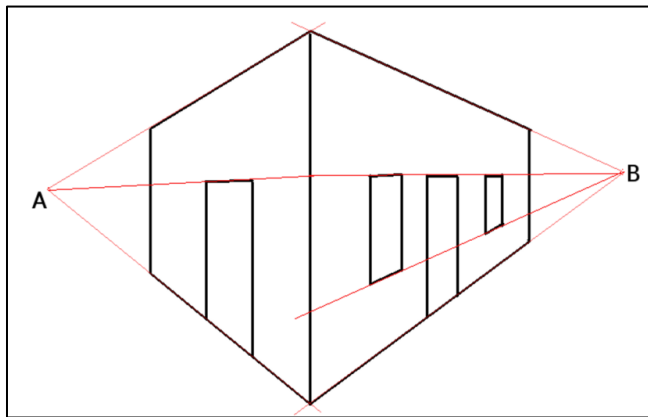
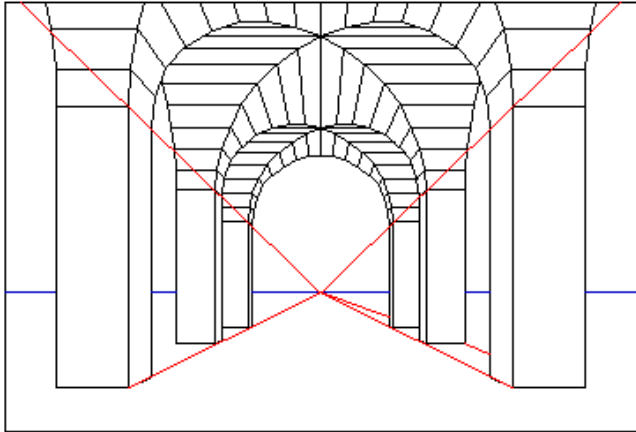


Fig: Examples of one-point perspective projection (Top-Left and Top-Right) and Examples of two-point perspective projection (Bottom-Left and Bottom-Right)

# Additional Reading

- The *three-point* perspective.

Thank You