

CMSC427

Transformations II:

Viewing

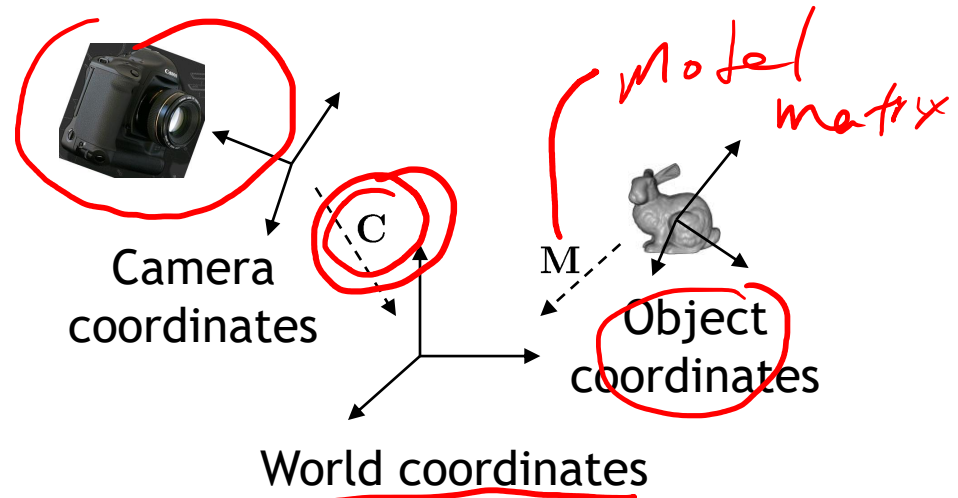
Credit: some slides from Dr. Zwicker



Viewing transformations: the virtual camera

Need to know

- Where is the camera?
- What lens does it have?



short lens



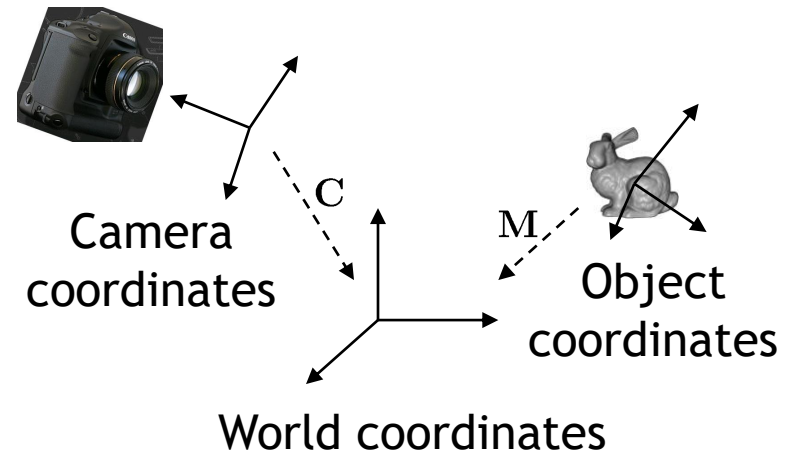
big long focal length



Viewing transformations: the virtual camera

Need to know

- Where is the camera?
 - CAMERA TRANSFORM
- What lens does it have?
 - PROJECTIVE TRANSFORM



Virtual camera routines in Processing

- Camera (where)
- beginCamera()
- camera()
- endCamera()

place

*transforms
inbetween*

- Projective (length of lens)
- frustum()
- ortho()
- perspective()

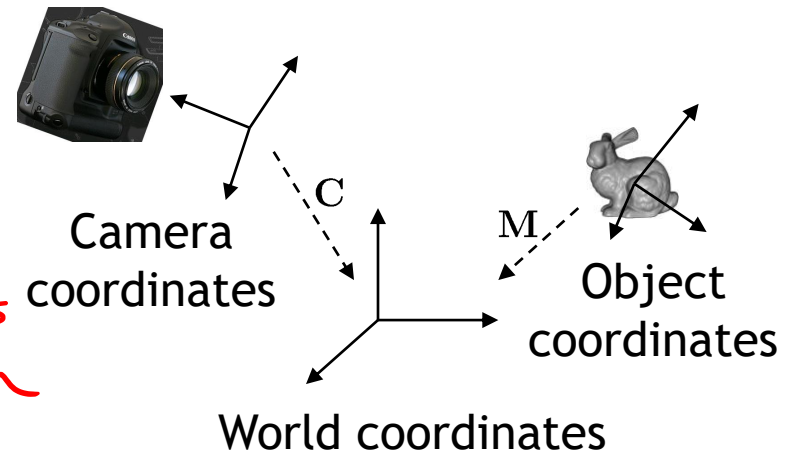
later

- Tracing *3 matrices*

- printCamera() -

- printProjection() -

model matrix printMatrix()



Camera routine in Processing

```
void setup() {  
  size(640, 360, P3D);  
}
```

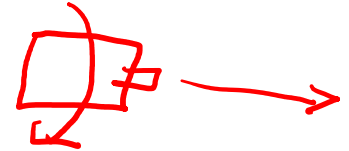
```
void draw() {  
  background(0);
```

```
    camera(width/2, height/2, (height/2) / tan(PI/6),  
           width/2, height/2, 0, 0, 1, 0);
```

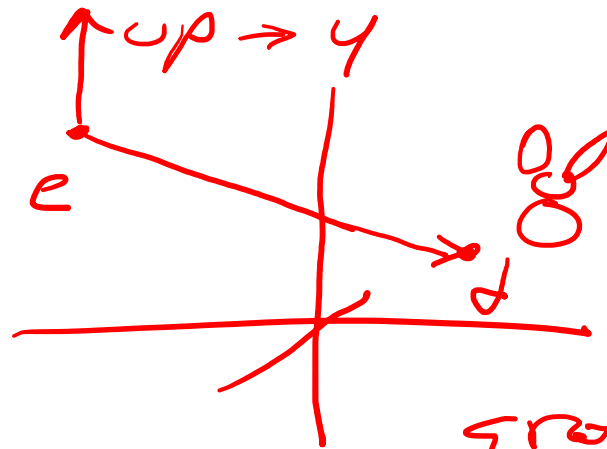
```
    translate(width/2, height/2, -100);  
    stroke(255);  
    noFill();  
    box(200);  
}
```

$(pt, pt, vector)$

$Camera(eye_x, eye_y, eye_z,$
 $dx, dy, dz,$
 $vp_x, vp_y, vp_z)$



vp_x
 vp_y
 vp_z

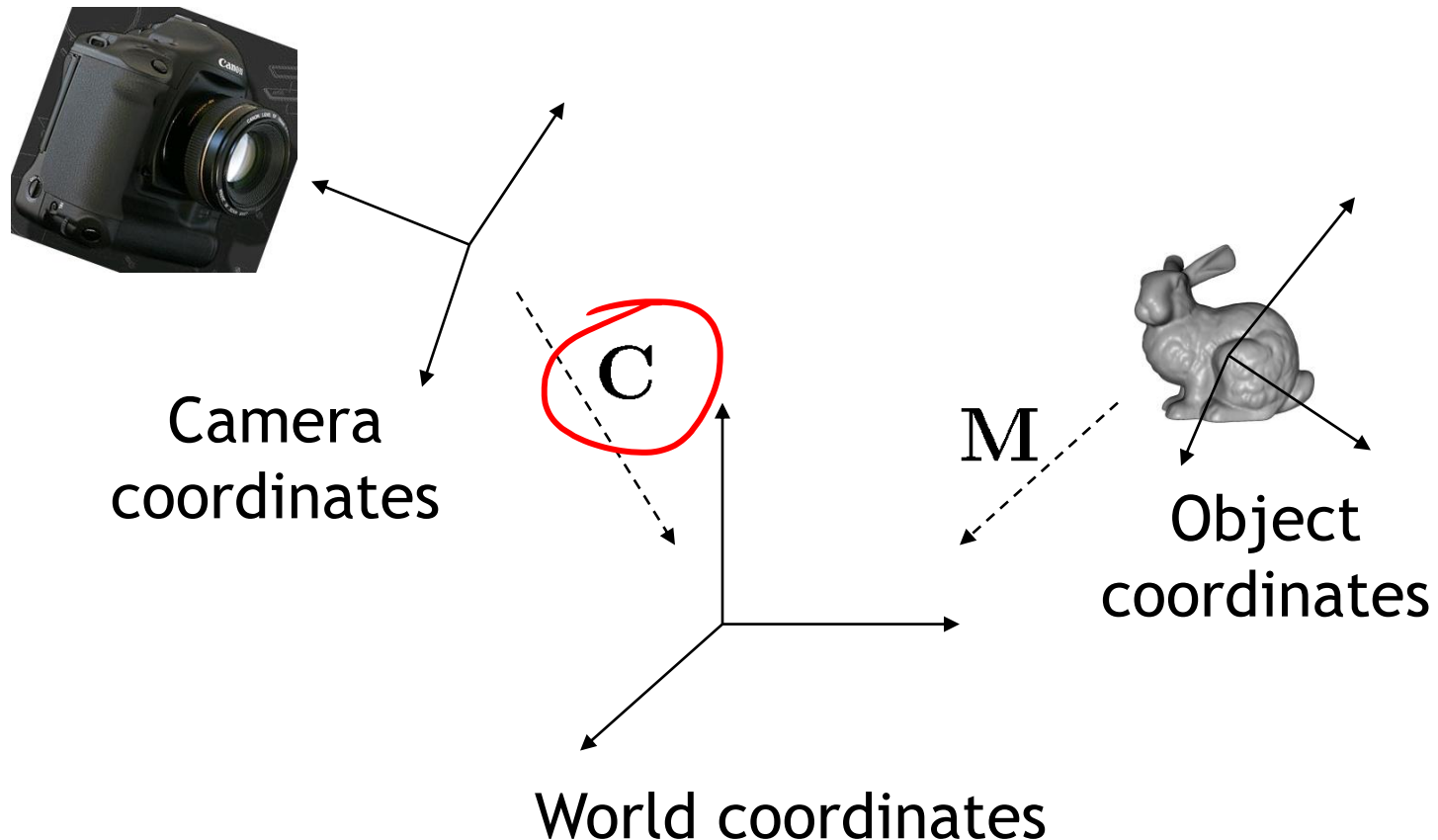


ground x,z



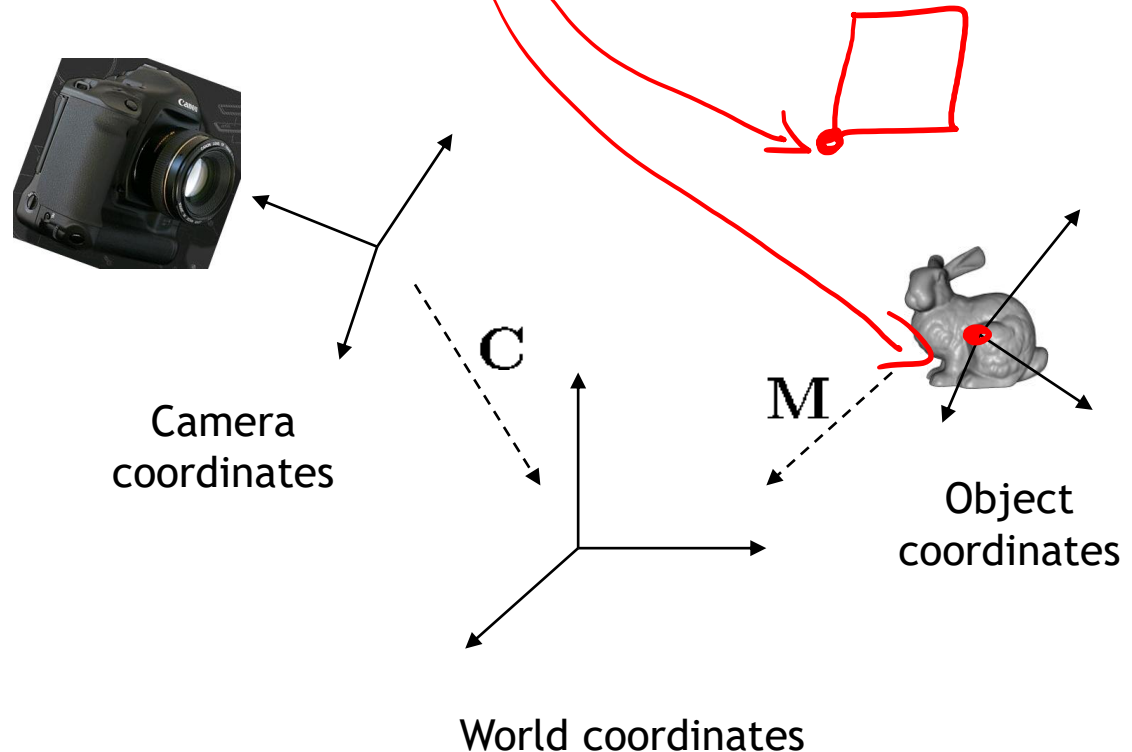
Common coordinate systems

- Camera, world, and object coordinates
- Matrices for change of coordinates $\mathbf{C}$, $\mathbf{M}$



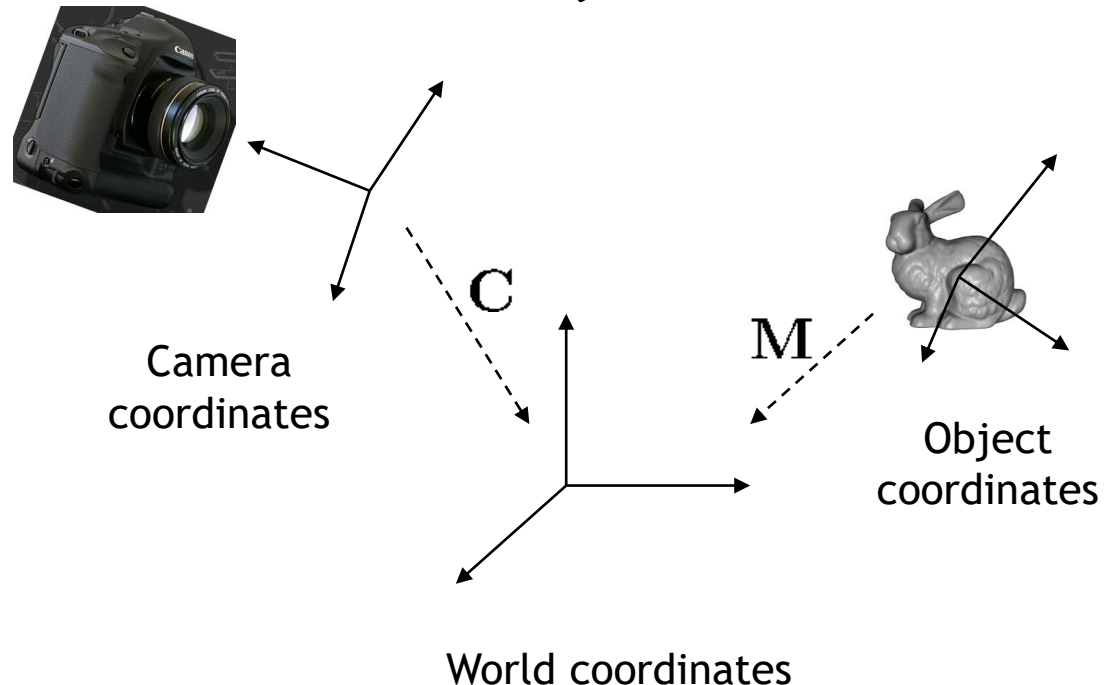
Object coordinates

- Coordinates the object is defined with
- Often origin is in middle, base, or corner of object
- No right answer, whatever was convenient for the creator of the object



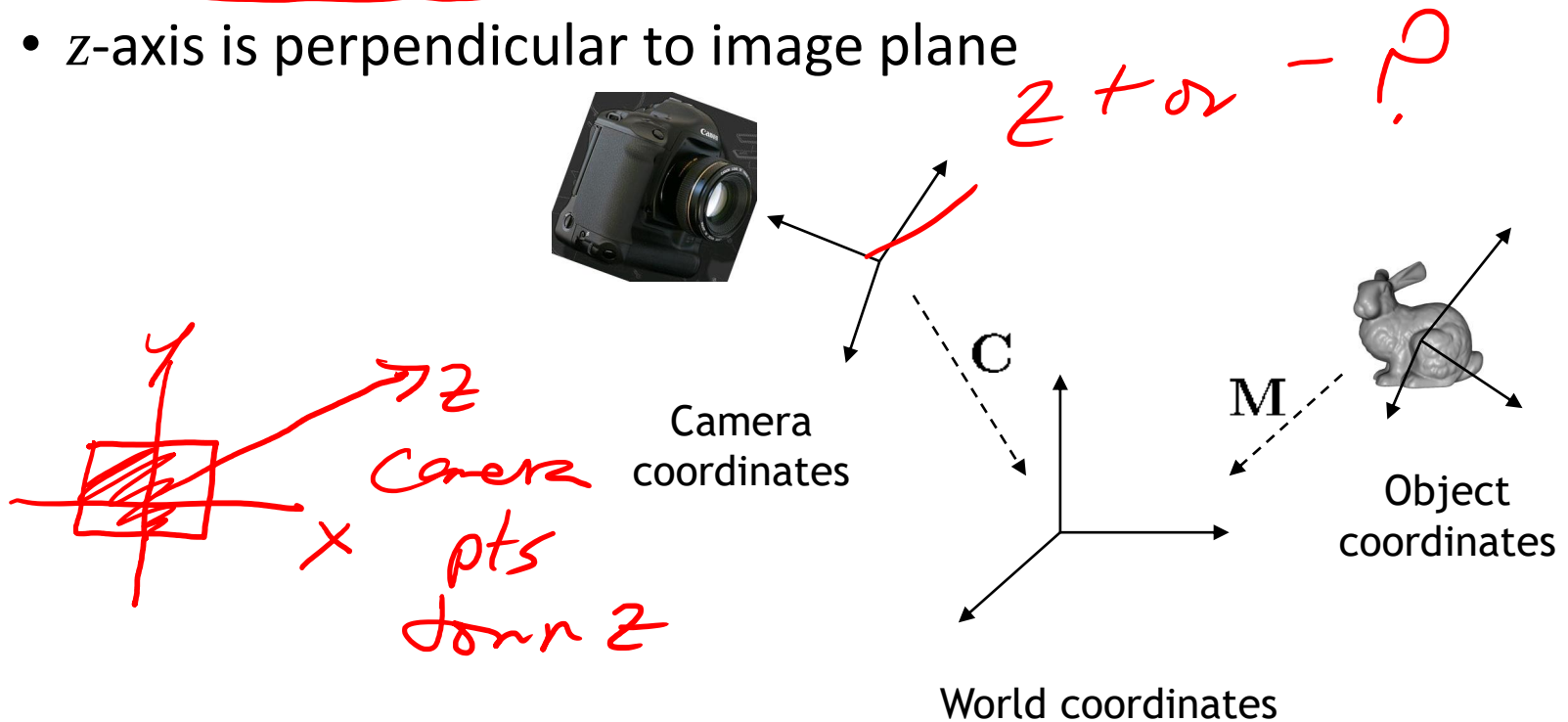
World coordinates

- “World space”
- Common reference frame for all objects in the scene
- Chosen for convenience, no right answer
 - If there is a ground plane, usually x - y is horizontal and z points up



Camera coordinate system

- “Camera space”
- Origin defines center of projection of camera
- Common convention in 3D graphics
 - x-y plane is parallel to image plane
 - z-axis is perpendicular to image plane

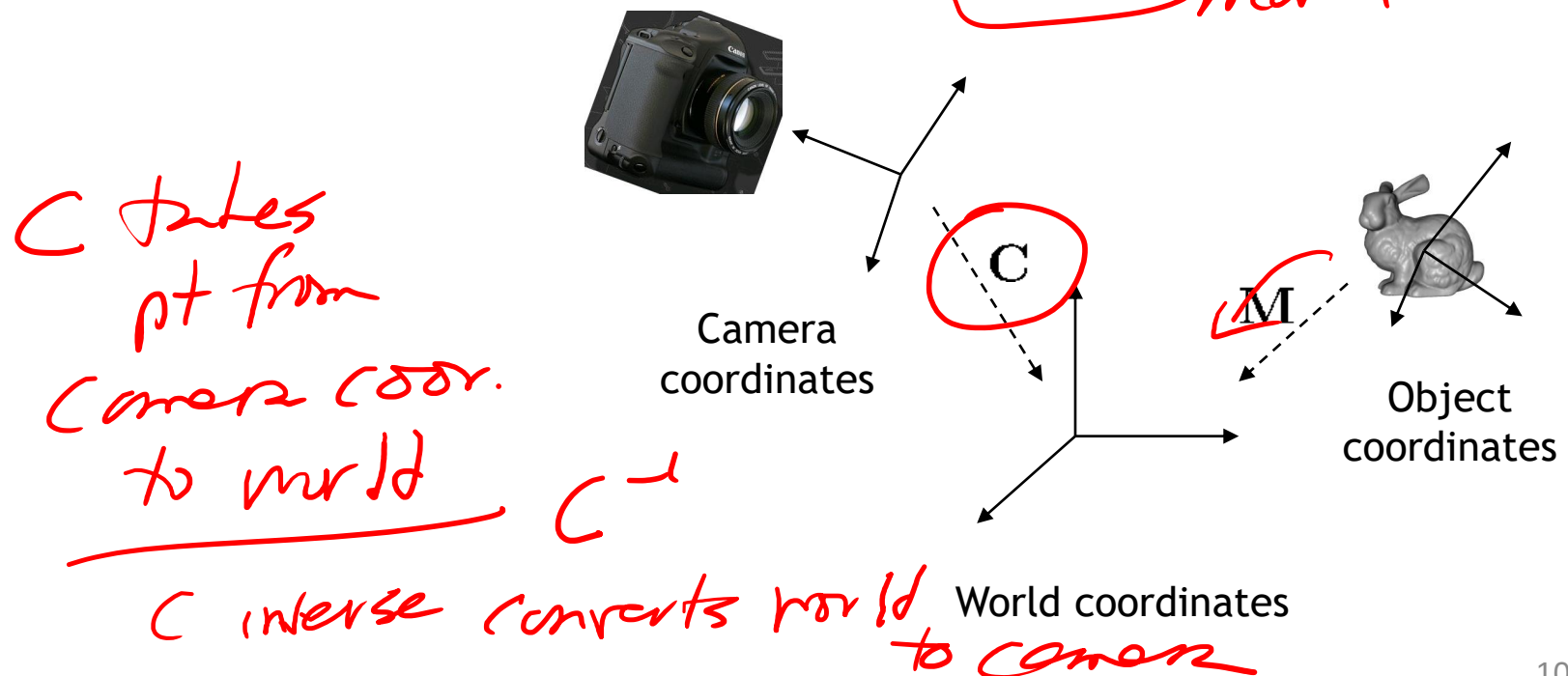


Camera coordinate system

- “Camera matrix” defines transformation from **camera to world** coordinates
 - Placement of camera in world
- Transformation from object to camera coordinates

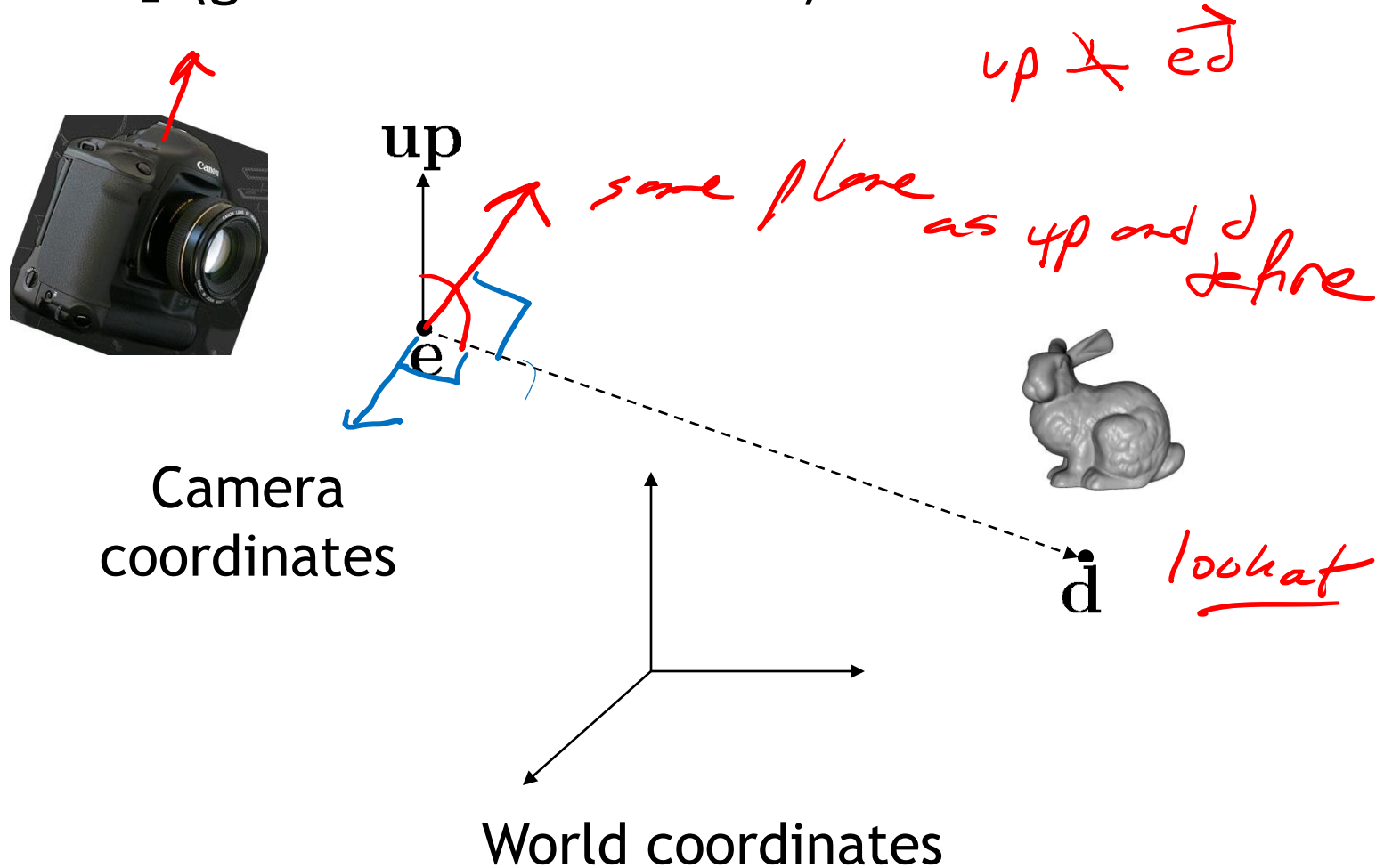
$$\mathbf{p}_{camera} = \mathbf{C}^{-1} \mathbf{M} \mathbf{p}_{object}$$

point model



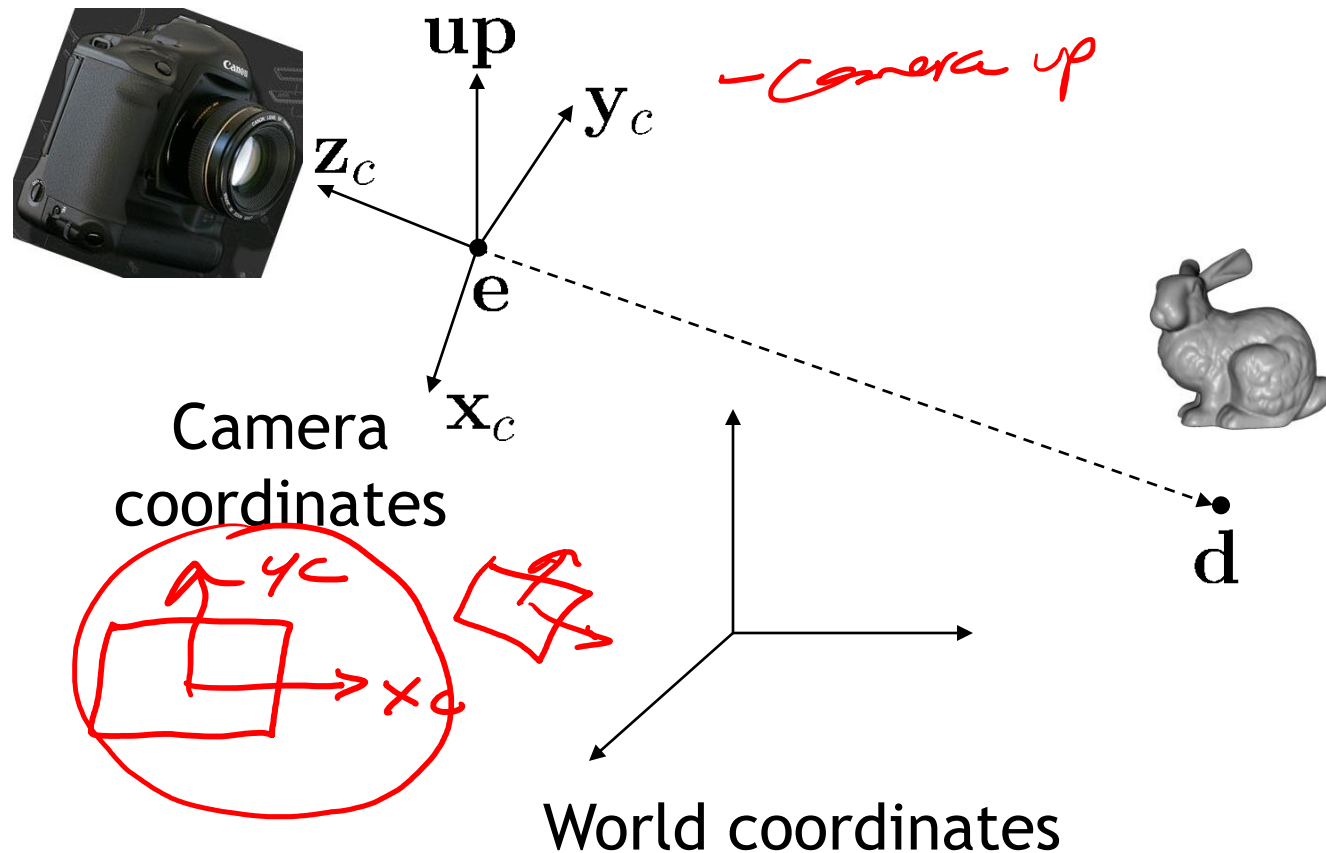
Camera matrix

- Construct from center of projection e , look at d , up-vector up (given in world coords.)



Camera matrix

- Construct from center of projection e , look at d , up-vector up (given in world coords.)



Camera matrix

• z-axis
 $z_c = \frac{e - d}{\|e - d\|}$

• x-axis
 $x_c = \frac{\text{up} \times z_c}{\|\text{up} \times z_c\|}$

• y-axis
 $y_c = z_c \times x_c$

*SIGN errors
wrong order
on $e - d$,
 $\text{up} \times z$
or $z \times x$*

