

# Computação Gráfica

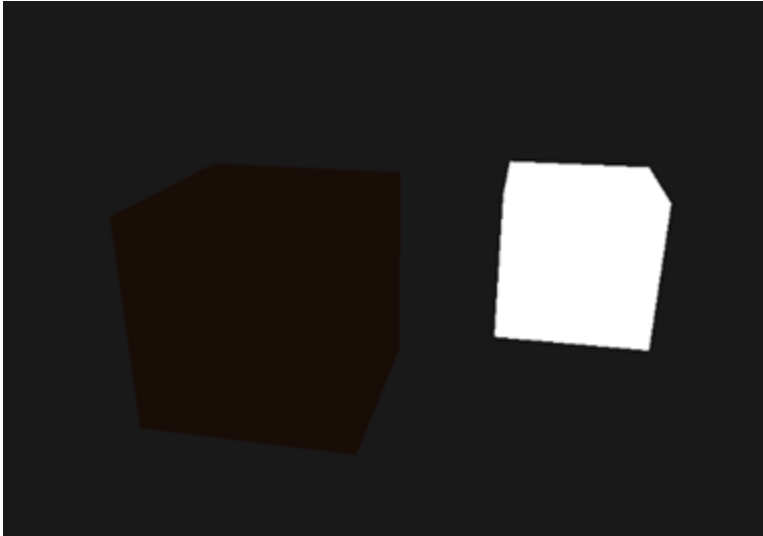
Aula 16: Revisão 4

# Revisão

- Iluminação
- Interpolação

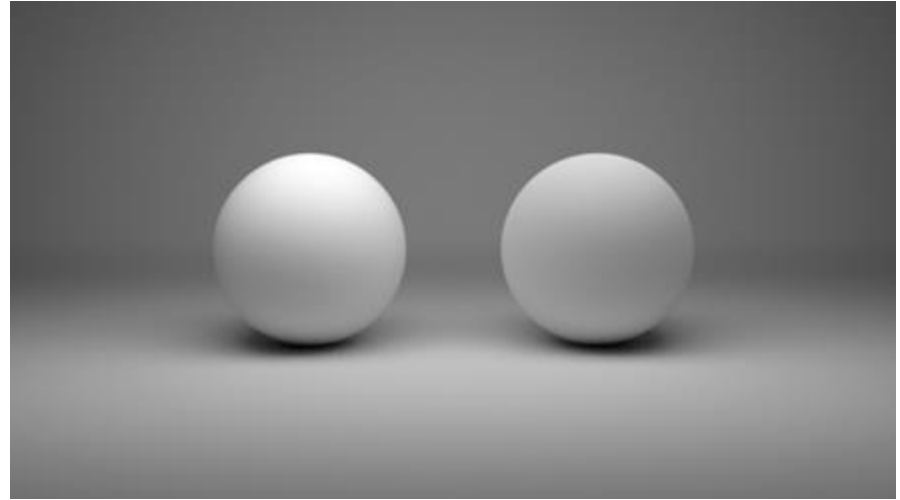
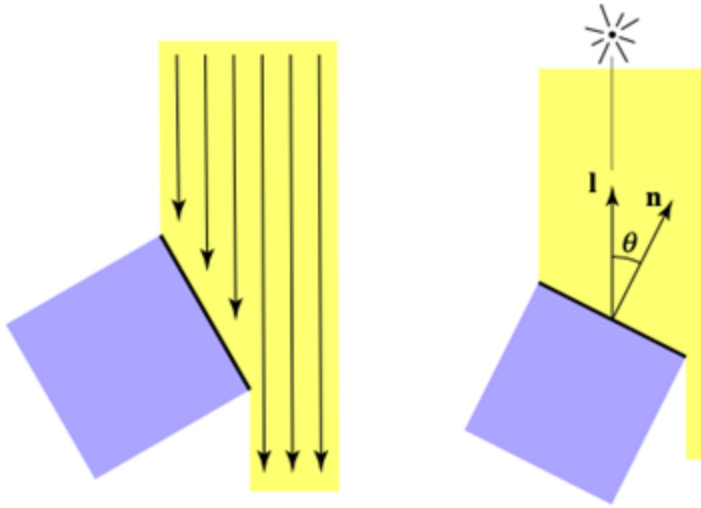
# Iluminação/Reflexão Ambiente

A iluminação ambiente (AmbientLight) resulta da dispersão e reflexão da luz originalmente emitida diretamente por fontes de luz. A quantidade de luz ambiente está associada às luzes individuais na cena. Esta é uma aproximação grosseira de como a reflexão ambiental realmente ocorre na natureza.



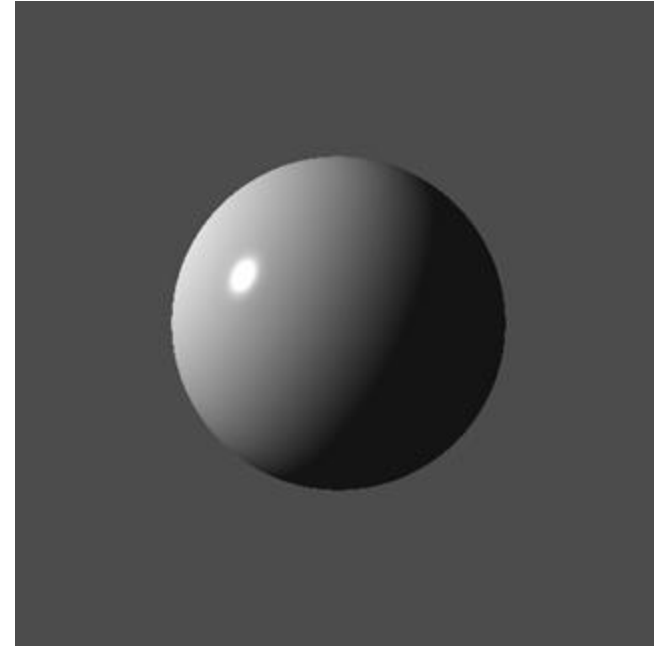
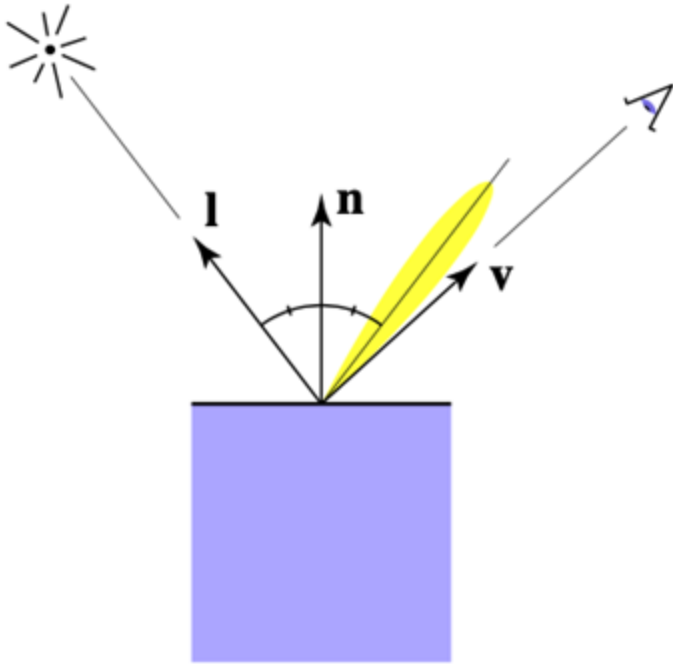
# Iluminação/Reflexão Difusa

A iluminação difusa (DiffuseLight) espalha a luz de forma uniforme, assim não depende do ponto de vista, porém depende da sua relação com a normal da superfície.



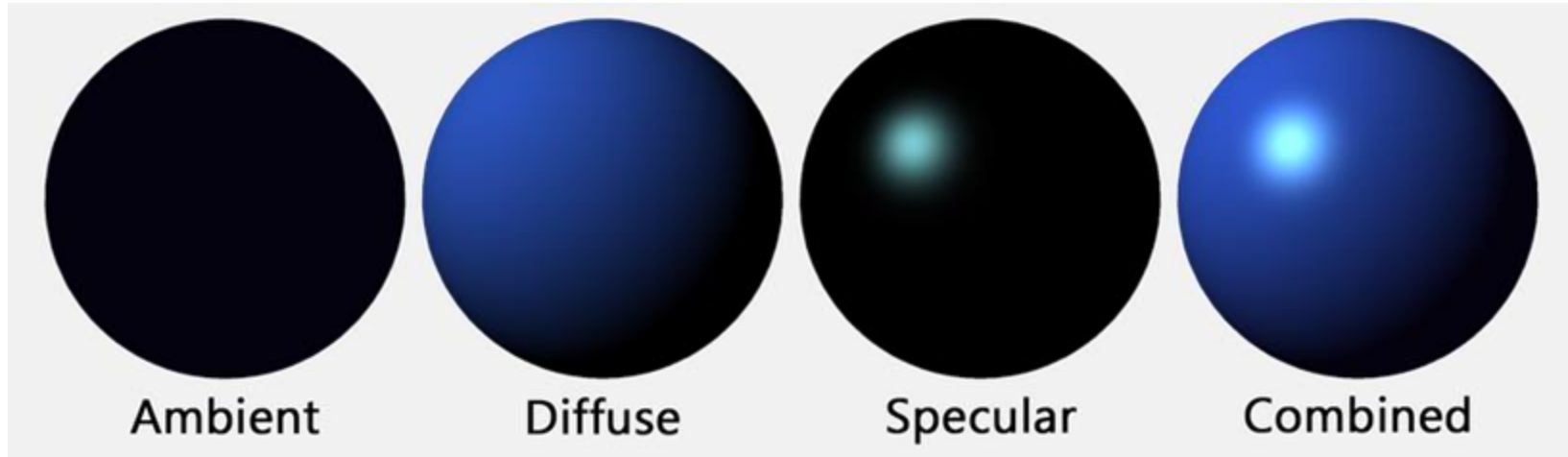
# Iluminação/Reflexão Especular

A iluminação especular (SpecularLight) possui uma maior reflexividade, assim dependendo do ponto de vista é possível ver pontos mais iluminados.



# Resultado Final

$$\mathbf{I}_{\text{rgb}} = O_{\text{E rgb}} + \text{SUM}( I_{\text{Lrgb}} \times (\text{ambient}_i + \text{diffuse}_i + \text{specular}_i))$$



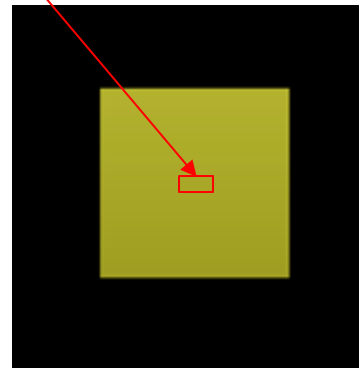
# Exemplo X3D

```
<Viewpoint position="0 0 10"/>
<NavigationInfo headlight='false'/>

<DirectionalLight direction="0 -0.8 -0.6" color="1 1 1" intensity="1" ambientIntensity="0"/>

<Transform>
  <Shape>
    <Box/>
    <Appearance>
      <Material specularColor='1.0 1.0 1.0' diffuseColor='1.0 1.0 0.0' shininess='0.2'
        ambientIntensity="0.2" emissiveColor="0 0 0"/>
    </Appearance>
  </Shape>
</Transform>
```

Qual a cor do pixel?



$$\mathbf{I}_{Lrgb} = (1.0, 1.0, 1.0) \quad \mathbf{I}_i = 1.0 \quad \mathbf{I}_{ia} = 0.0$$

$$\mathbf{O}_{Ergb} = (0.0, 0.0, 0.0) \quad \mathbf{O}_{Drgb} = (1.0, 1.0, 0.0) \quad \mathbf{O}_{Srgb} = (1.0, 1.0, 1.0) \quad \mathbf{O}_a = 0.2$$

$$\mathbf{L} = (0.0, 0.8, 0.6)$$

$$\mathbf{N} = (0.0, 0.0, 1.0)$$

$$\mathbf{v} = (0.0, 0.0, 1.0) * \text{ [Supondo no meio da tela]}$$

\*(essa é uma aproximação, mas podem usar no projeto se desejarem)

$$\mathbf{N} \cdot \mathbf{L} = 0.6$$

$$(\mathbf{L} + \mathbf{v}) / |\mathbf{L} + \mathbf{v}| = (0.0, 0.8, 1.6) / 1.79$$

$$(\mathbf{L} + \mathbf{v}) / |\mathbf{L} + \mathbf{v}| = (0.0, 0.45, 0.90)$$

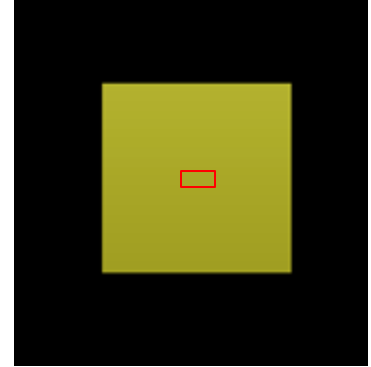
$$\mathbf{N} \cdot ((\mathbf{L} + \mathbf{v}) / |\mathbf{L} + \mathbf{v}|) = 0.9$$

# Exemplo X3D

```
<Viewpoint position="0 0 10"/>
<NavigationInfo headlight='false'/>

<DirectionalLight direction="0 -0.8 -0.6" color="1 1 1" intensity="1" ambientIntensity="0"/>

<Transform>
  <Shape>
    <Box/>
    <Appearance>
      <Material specularColor='1.0 1.0 1.0' diffuseColor='1.0 1.0 0.0' shininess='0.2'
        ambientIntensity="0.2" emissiveColor="0 0 0"/>
    </Appearance>
  </Shape>
</Transform>
```



$$\mathbf{ambient}_i = I_{ia} \times O_{Drgb} \times O_a = 0.0 \times (1.0, 1.0, 0.0) \times 0.2 = (0.0, 0.0, 0.0)$$

$$\mathbf{diffuse}_i = I_i \times O_{Drgb} \times (\mathbf{N} \cdot \mathbf{L}) = 1.0 \times (1.0, 1.0, 0.0) \times 0.6 = (0.6, 0.6, 0.0)$$

$$\begin{aligned} \mathbf{specular}_i &= I_i \times O_{Srgb} \times (\mathbf{N} \cdot ((\mathbf{L} + \mathbf{v}) / |\mathbf{L} + \mathbf{v}|))^{shininess} \times 128 \\ &= 1.0 \times (1.0, 1.0, 1.0) \times 0.9^{25.6} = (0.07, 0.07, 0.07) \end{aligned}$$

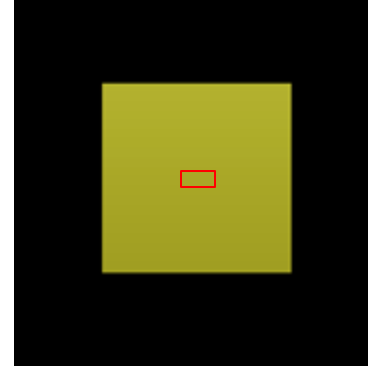


# Exemplo X3D

```
<Viewpoint position="0 0 10"/>
<NavigationInfo headlight='false' />

<DirectionalLight direction="0 -0.8 -0.6" color="1 1 1" intensity="1" ambientIntensity="0"/>

<Transform>
  <Shape>
    <Box />
    <Appearance>
      <Material specularColor='1.0 1.0 1.0' diffuseColor='1.0 1.0 0.0' shininess='0.2'
        ambientIntensity="0.2" emissiveColor="0 0 0"/>
    </Appearance>
  </Shape>
</Transform>
```



$$I_{\text{rgb}} = O_{\text{E rgb}} + \text{SUM}(I_{\text{Lrgb}} \times (\text{ambient}_i + \text{diffuse}_i + \text{specular}_i))$$

$$I_{\text{rgb}} = (0.0, 0.0, 0.0) + \text{SUM}((1.0, 1.0, 1.0) \times ((0.0, 0.0, 0.0) + (0.6, 0.6, 0.0) + (0.07, 0.07, 0.07)))$$

$$I_{\text{rgb}} = (0.0, 0.0, 0.0) + \text{SUM}((1.0, 1.0, 1.0) \times (0.67, 0.67, 0.07))$$

$$I_{\text{rgb}} = (0.0, 0.0, 0.0) + (0.67, 0.67, 0.07)$$

$$I_{\text{rgb}} = (0.67, 0.67, 0.07)$$



# Hermite spline interpolation (X3D simplificado)

$(t_i \leq \text{fraction} < t_{i+1})$ , where  $t_i$  is the key at (i), and  $t_{i+1}$  is the key at (i+1)

$$s = (t - t_i) / (t_{i+1} - t_i)$$

$$\mathbf{v}_s = \mathbf{S}^T \mathbf{H} \mathbf{C}$$

$$\mathbf{S} = \begin{vmatrix} s^3 \\ s^2 \\ s \\ 1 \end{vmatrix} \quad \mathbf{H} = \begin{vmatrix} 2 & -2 & 1 & 1 \\ -3 & 3 & -2 & -1 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \end{vmatrix} \quad \mathbf{C} = \begin{vmatrix} \mathbf{v}_i \\ \mathbf{v}_{i+1} \\ \mathbf{T}_i^0 \\ \mathbf{T}_{i+1}^1 \end{vmatrix}$$

If the velocity vector is not specified, it is calculated as follows:

$$\mathbf{T}_i = (\mathbf{v}_{i+1} - \mathbf{v}_{i-1}) / 2$$

If the interpolator is not closed, and the first and last velocity vectors are not specified by the author:

$$\mathbf{T}_0^0 = \mathbf{T}_0^1 = \mathbf{T}_{N-1}^0 = \mathbf{T}_{N-1}^1 = 0$$

# Exemplo X3D

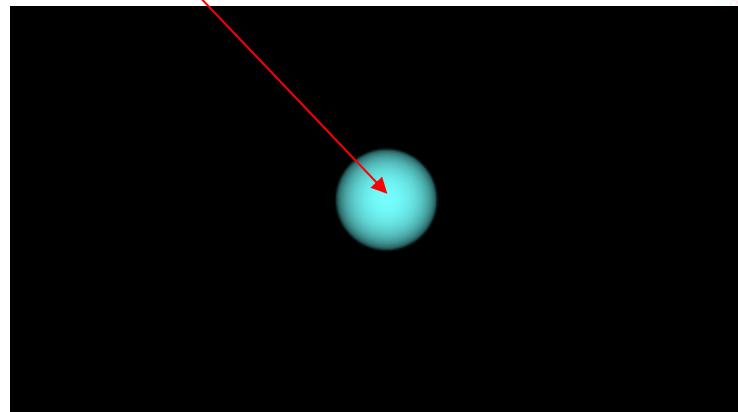
```
<TimeSensor DEF='relogio' cycleInterval='8' loop='true'/>

<SplinePositionInterpolator DEF="move" closed="false"
  key="      0.00    0.2    0.4    0.6    0.8    1.00"
  keyValue="-5 -1 0  -3 1 0  -1 -1 0  1 1 0  3 -1 0  5 1 0"/>
```

```
<Transform DEF='esfera'>
  <Shape>
    <Sphere/>
    <Appearance>
      <Material diffuseColor='0.0 1.0 1.0' />
    </Appearance>
  </Shape>
</Transform>
```

```
<ROUTE fromNode='relogio' fromField='fraction_changed' toNode='move' toField='set_fraction' />
<ROUTE fromNode='move' fromField='value_changed' toNode='esfera' toField='translation' />
```

Qual a posição no meio ( $t=0.5$ )?



$$s = (t - t_i) / (t_{i+1} - t_i) = (0.5 - 0.4) / (0.6 - 0.4) = 0.1 / 0.2 = 0.5$$

$$\mathbf{T}_i = (\mathbf{v}_{i+1} - \mathbf{v}_{i-1}) / 2:$$

$$\mathbf{T}_2 = (\mathbf{v}_3 - \mathbf{v}_1) / 2 = ( (1, 1, 0) - (-3, 1, 0) ) / 2 = (4, 0, 0) / 2 = (2, 0, 0)$$

$$\mathbf{T}_3 = (\mathbf{v}_4 - \mathbf{v}_2) / 2 = ( (3, -1, 0) - (-1, -1, 0) ) / 2 = (4, 0, 0) / 2 = (2, 0, 0)$$

# Exemplo X3D

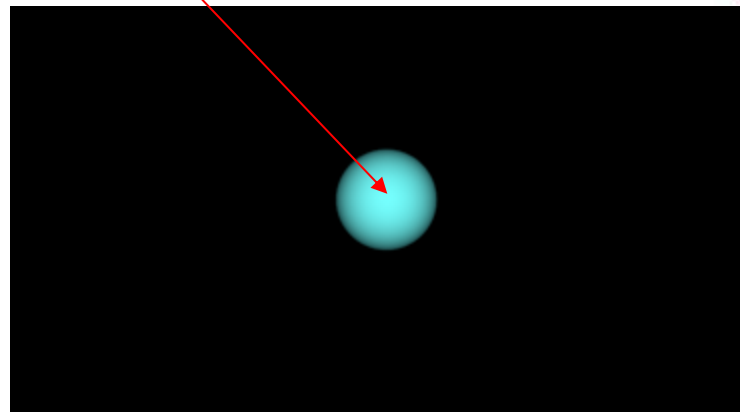
```
<TimeSensor DEF='relogio' cycleInterval='8' loop='true'/>

<SplinePositionInterpolator DEF="move" closed="false"
  key="      0.00    0.2    0.4    0.6    0.8    1.00"
  keyValue="-5 -1 0  -3 1 0  -1 -1 0  1 1 0  3 -1 0  5 1 0"/>

<Transform DEF='esfera'>
  <Shape>
    <Sphere/>
    <Appearance>
      <Material diffuseColor='0.0 1.0 1.0' />
    </Appearance>
  </Shape>
</Transform>

<ROUTE fromNode='relogio' fromField='fraction_changed' toNode='move' toField='set_fraction' />
<ROUTE fromNode='move' fromField='value_changed' toNode='esfera' toField='translation' />
```

Qual a posição no meio (t=0.5)?



$$S = \begin{bmatrix} 0.125 \\ 0.25 \\ 0.5 \\ 1 \end{bmatrix}^T \quad H = \begin{bmatrix} 2 & -2 & 1 & 1 \\ -3 & 3 & -2 & -1 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} \quad C = \begin{bmatrix} -1 & -1 & 0 \\ 1 & 1 & 0 \\ 2 & 0 & 0 \\ 2 & 0 & 0 \end{bmatrix}$$

$$\mathbf{v}_s = \mathbf{S}^T \mathbf{H} \mathbf{C}$$

# Exemplo X3D

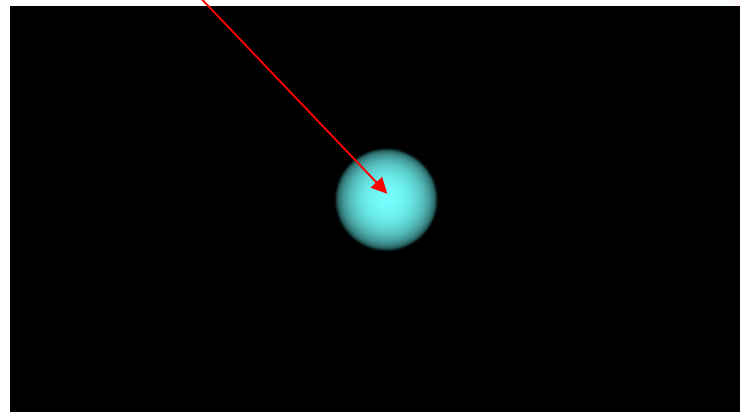
```
<TimeSensor DEF='relogio' cycleInterval='8' loop='true'/>

<SplinePositionInterpolator DEF="move" closed="false"
  key="      0.00    0.2    0.4    0.6    0.8    1.00"
  keyValue="-5 -1 0  -3 1 0  -1 -1 0  1 1 0  3 -1 0  5 1 0"/>

<Transform DEF='esfera'>
  <Shape>
    <Sphere/>
    <Appearance>
      <Material diffuseColor='0.0 1.0 1.0'/>
    </Appearance>
  </Shape>
</Transform>

<ROUTE fromNode='relogio' fromField='fraction_changed' toNode='move' toField='set_fraction'/>
<ROUTE fromNode='move' fromField='value_changed' toNode='esfera' toField='translation'/>
```

Qual a posição no meio (t=0.5)?



$$V_s = [0.125 \quad 0.25 \quad 0.5 \quad 1] \begin{bmatrix} 2 & -2 & 1 & 1 \\ -3 & 3 & -2 & -1 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} \cdot \begin{bmatrix} -1 & -1 & 0 \\ 1 & 1 & 0 \\ 2 & 0 & 0 \\ 2 & 0 & 0 \end{bmatrix} = [0 \quad 0 \quad 0]$$

# Computação Gráfica

Luciano Soares  
<lpsoares@insper.edu.br>