# NPTEL ONLINE CERTIFICATION COURSES

## Course Name: Deep Learning


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## Topic

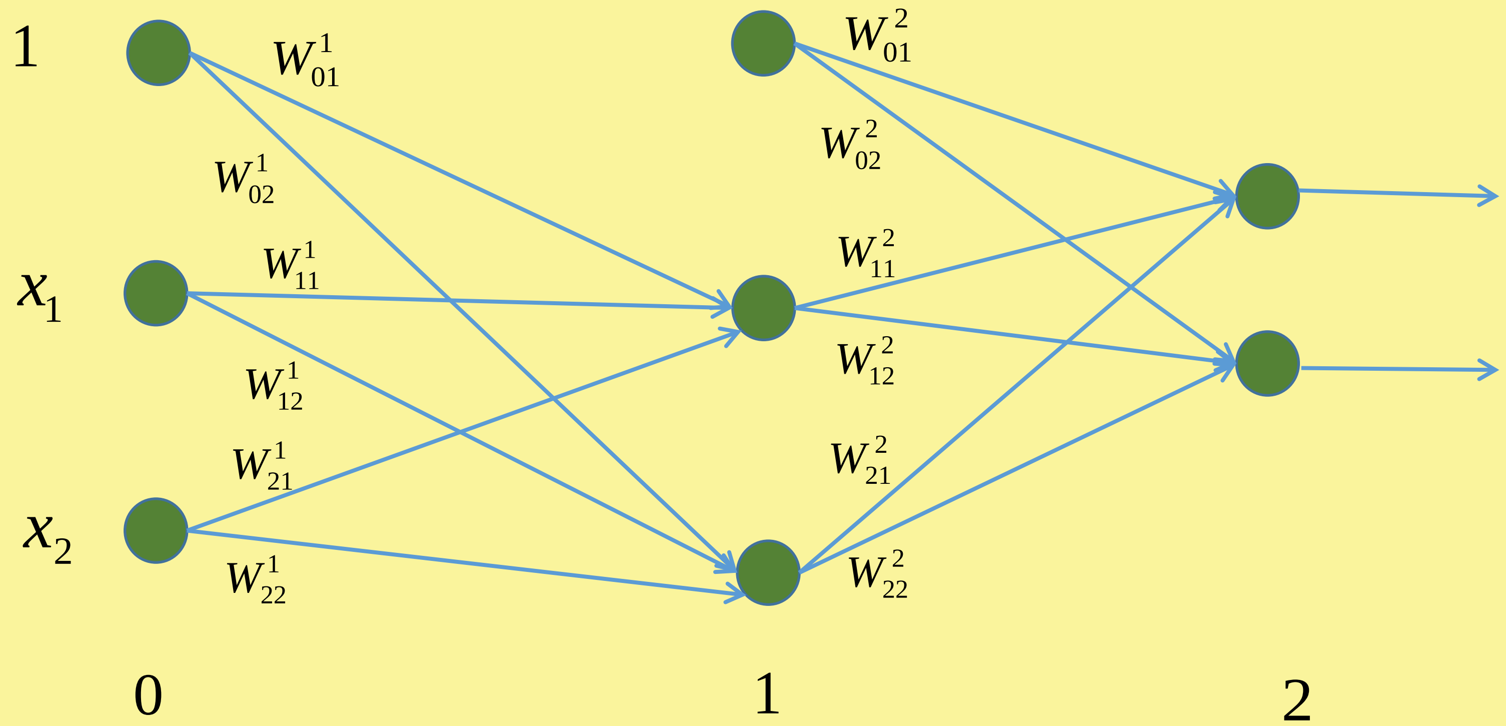
### Lecture 27: Back propagation Learning – Examples

CONCEPTS COVERED

Concepts Covered:

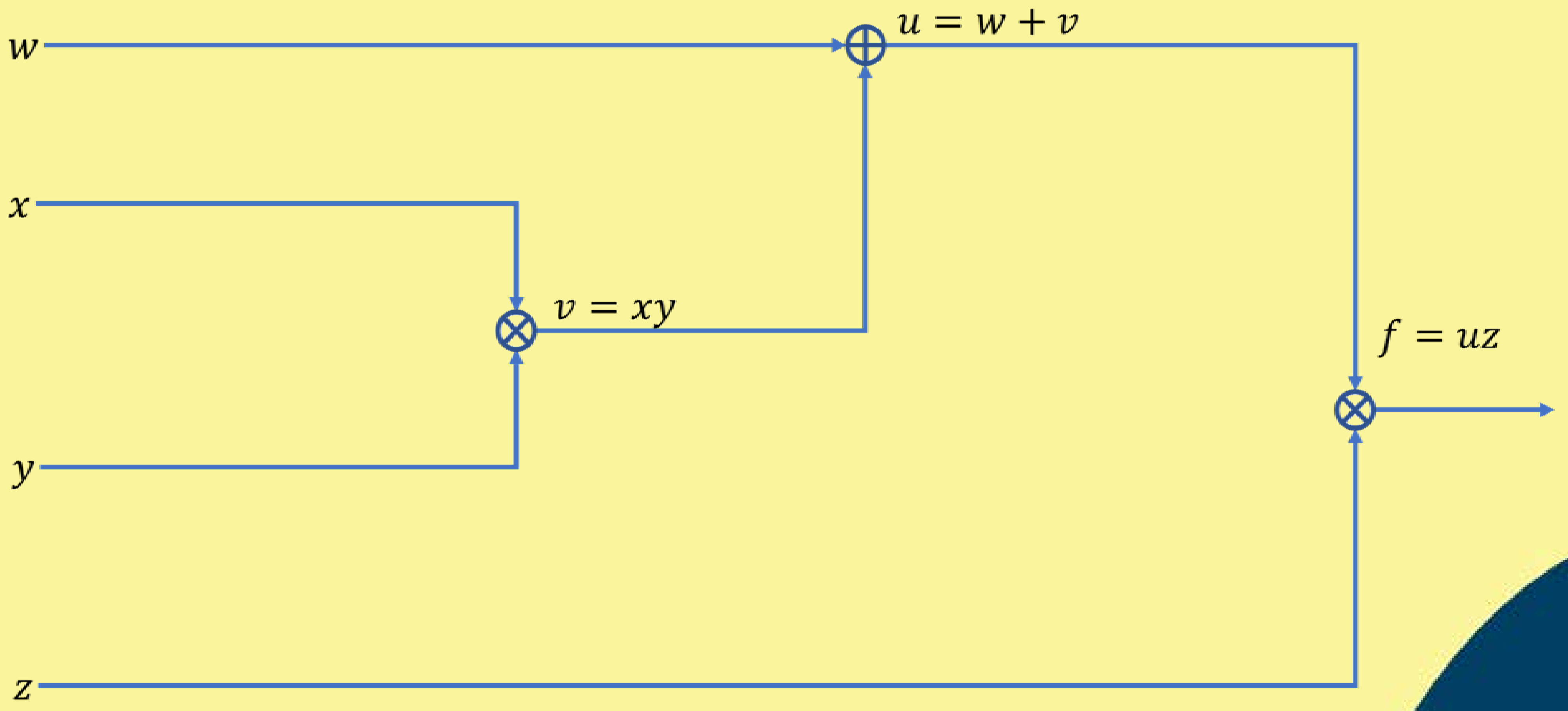
- Back Propagation Learning in MLP
- Back Propagation Learning – Network Level
- Back Propagation – Node Level

# Backpropagation at Network Level

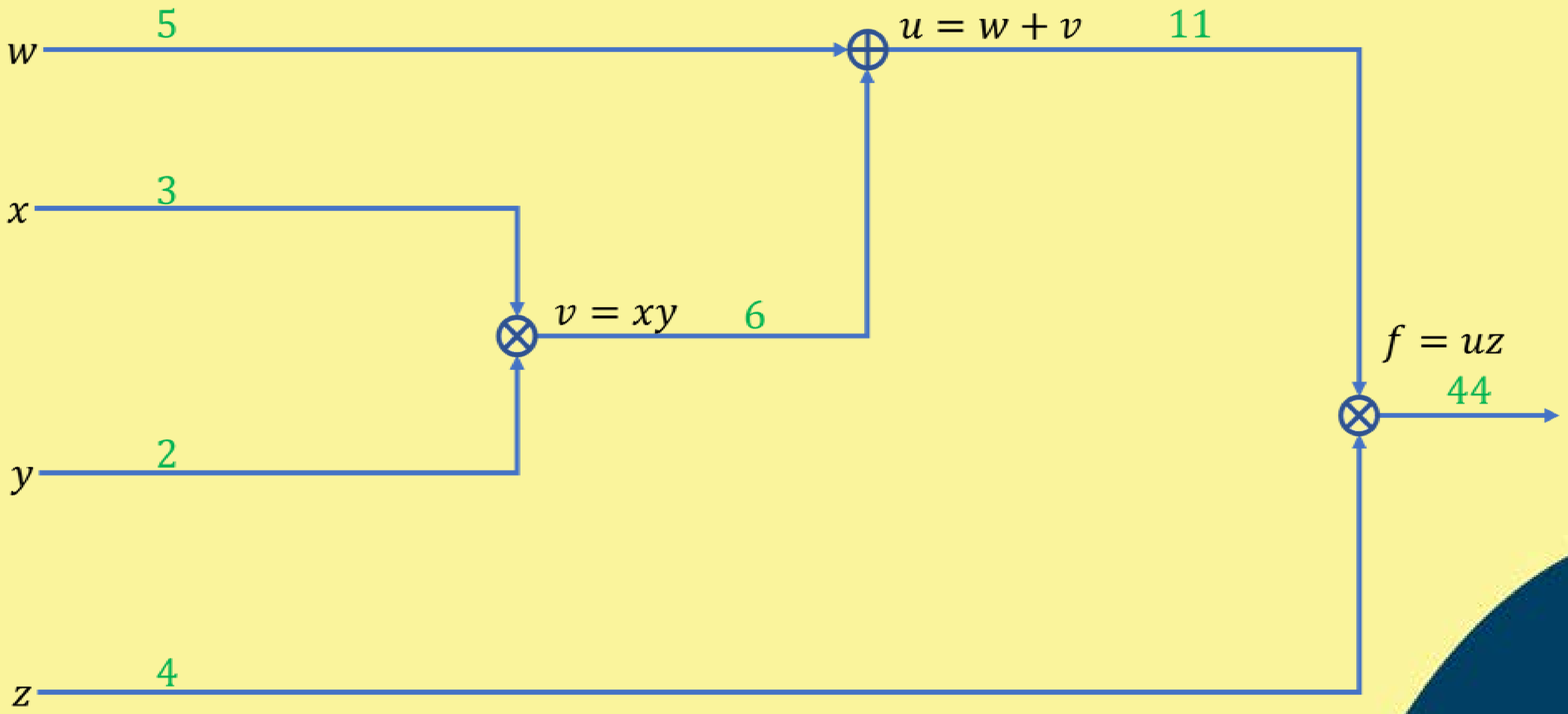


# Back Propagation Learning at Node Level

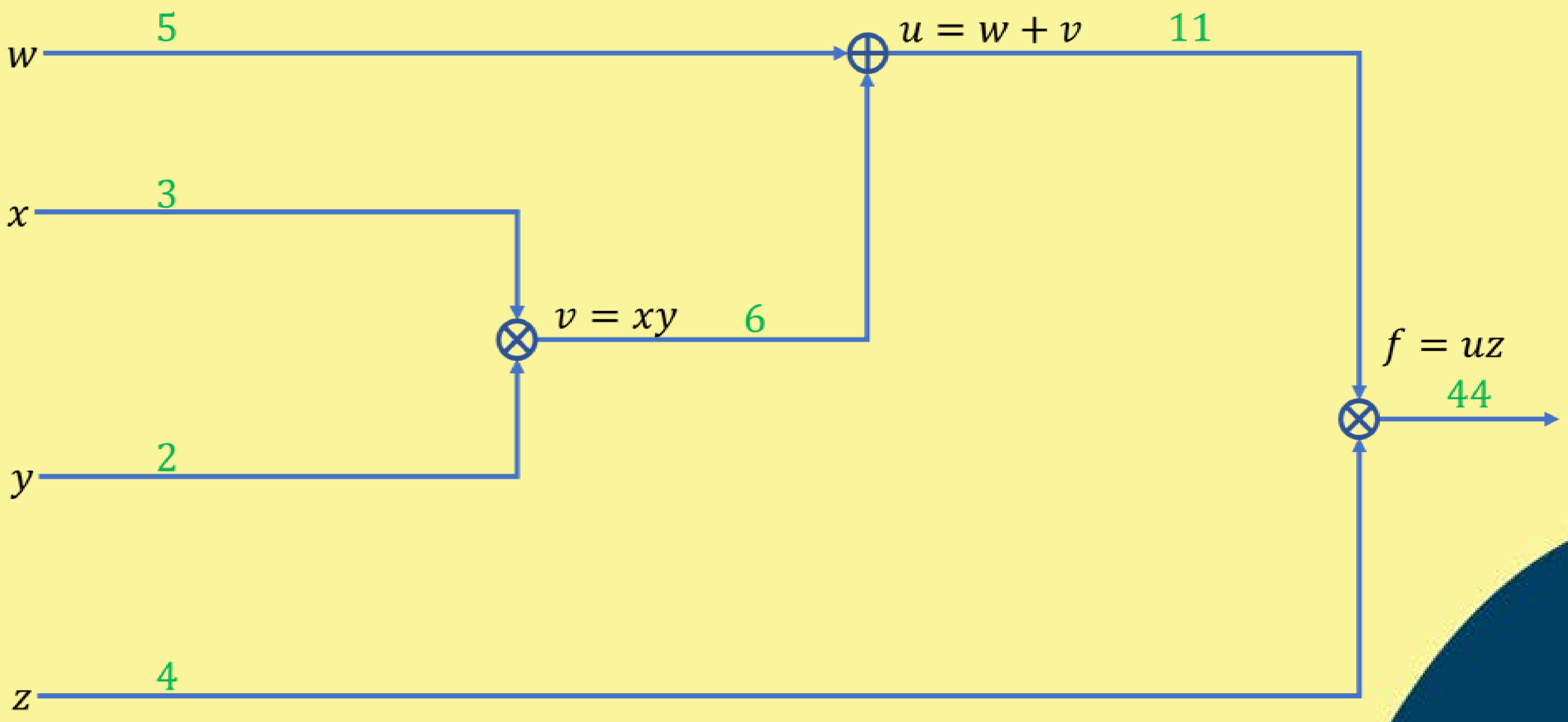
# Example: Node Architecture



# Example: Forward Pass



# Example: Backpropagation



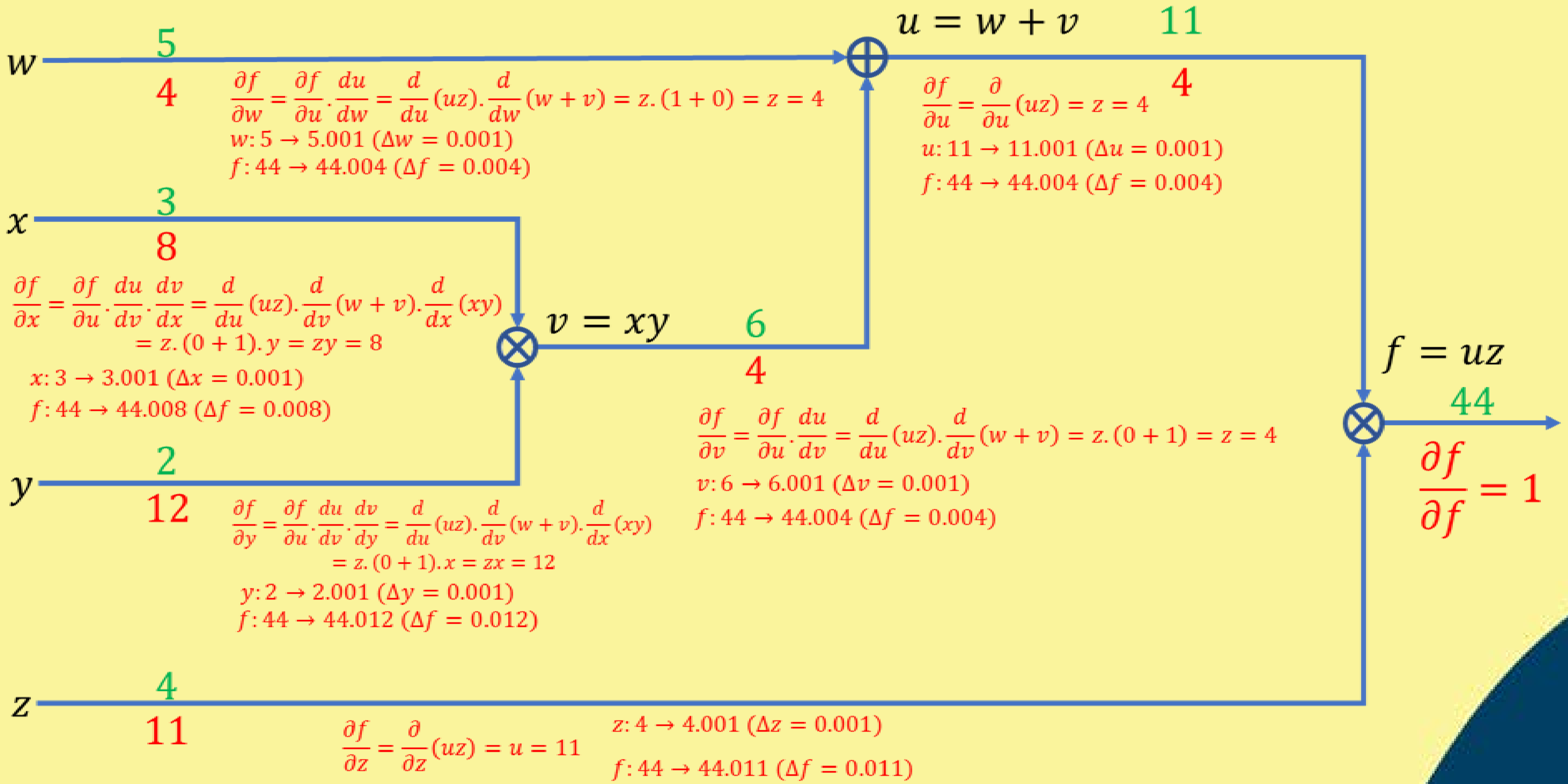
# Back propagation: Pseudo Code

```
# Set Input
  w=5; x=3; y=2; z=4

# Forward Pass

 v = x*y
 u = w+v
 f = u+z

# Backward Pass

 dfdu = z
 dfdz = u
 dfdw = 1*dfdu   # dudw = 1
 dfdv  = 1*dfdu   # dudv = 1
 dfdx  = y*dfdv    # dvdx = y
 dfdy  = x*dfdv    # dvdy = x
```

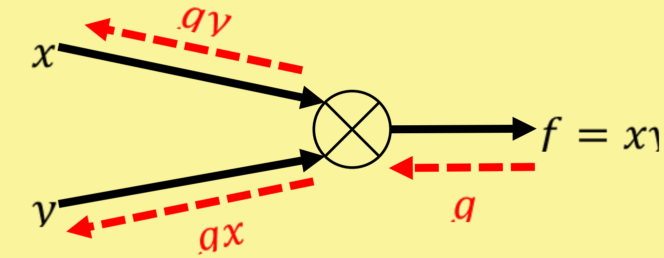
# Back propagation: Pseudo Code

```
# Set Input
  w=5; x=3; y=2; z=4

# Forward Pass

 v = x*y
 u = w+v
 f = u+z

# Backward Pass

  dfdu = z
  dfdz = u
  dfdw = 1*dfdu   # dudw = 1
  dfdv  = 1*dfdu   # dudv = 1
  dfdx  = y*dfdv    # dvdx = y
  dfdy  = x*dfdv    # dvdy = x
```

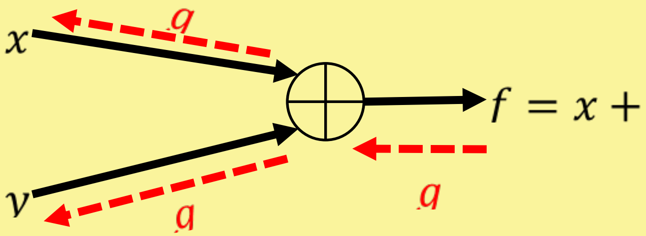
# Example: Calculate Gradients



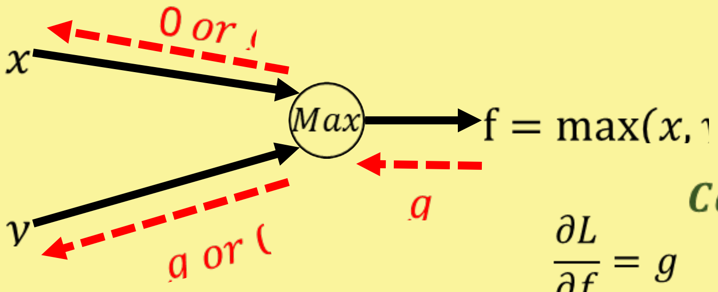
# Understanding Gradient Backward




$$\frac{\partial L}{\partial f} = g \qquad \frac{\partial f}{\partial x} = y; \ \frac{\partial f}{\partial y} = x; \ \frac{\partial L}{\partial x} = \frac{\partial L}{\partial f} \cdot \frac{\partial f}{\partial x} = gy; \ \frac{\partial L}{\partial y} = \frac{\partial L}{\partial f} \cdot \frac{\partial f}{\partial y} = gx$$




$$\frac{\partial L}{\partial f} = g \qquad \frac{\partial f}{\partial x} = 1; \ \frac{\partial f}{\partial y} = 1; \ \frac{\partial L}{\partial x} = \frac{\partial L}{\partial f} \cdot \frac{\partial f}{\partial x} = g; \ \frac{\partial L}{\partial y} = \frac{\partial L}{\partial f} \cdot \frac{\partial f}{\partial y} = g$$




$$\frac{\partial L}{\partial f} = g$$

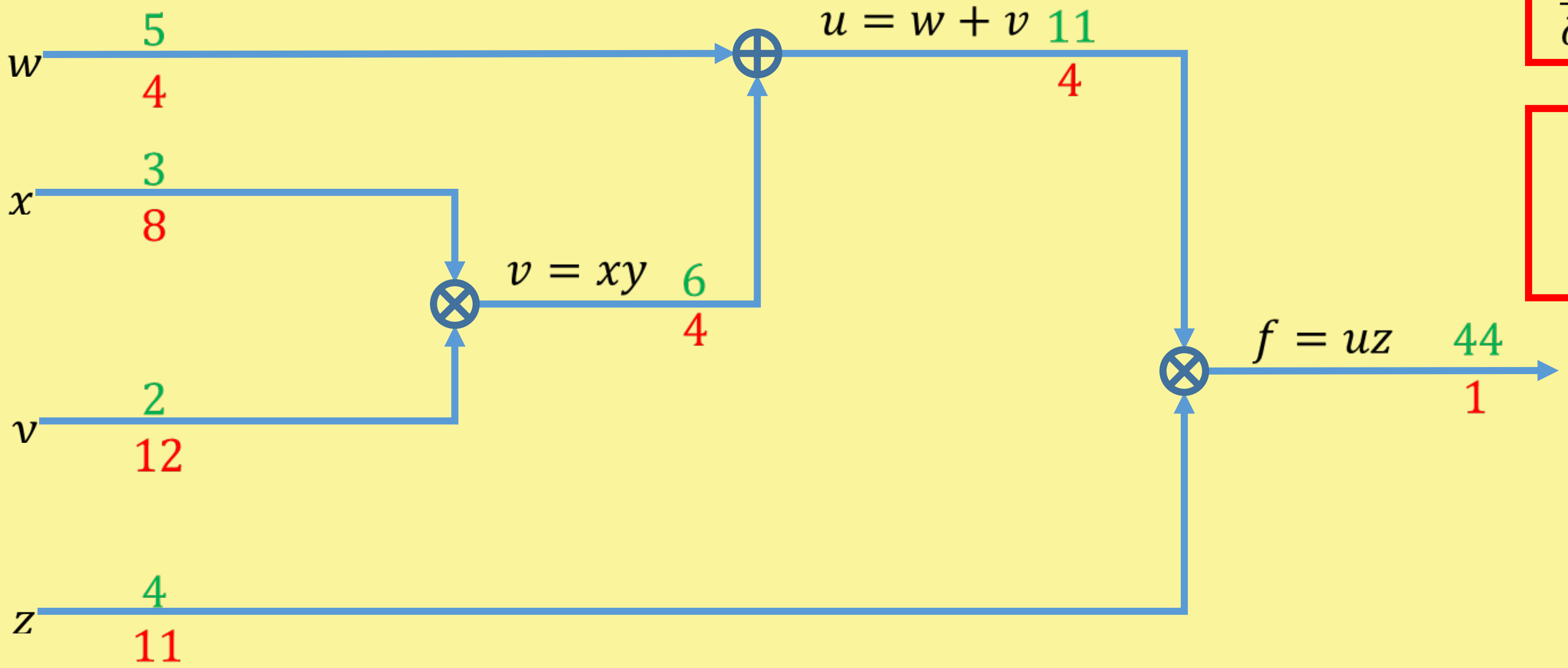
$\boldsymbol{Case - I: x > y; f = max(x, y) = x}$

$$\frac{\partial f}{\partial x} = 1; \ \frac{\partial f}{\partial y} = 0; \ \frac{\partial L}{\partial x} = \frac{\partial L}{\partial f} \cdot \frac{\partial f}{\partial x} = g \qquad \frac{\partial L}{\partial y} = \frac{\partial L}{\partial f} \cdot \frac{\partial f}{\partial y} = 0$$

$\boldsymbol{Case - II: x < y; f = max(x, y) = y}$

$$\frac{\partial f}{\partial x} = 0; \ \frac{\partial f}{\partial y} = 1; \ \frac{\partial L}{\partial x} = \frac{\partial L}{\partial f} \cdot \frac{\partial f}{\partial x} = 0; \ \frac{\partial L}{\partial y} = \frac{\partial L}{\partial f} \cdot \frac{\partial f}{\partial y} = g$$

# Previous example: different approach




$$f = x +$$

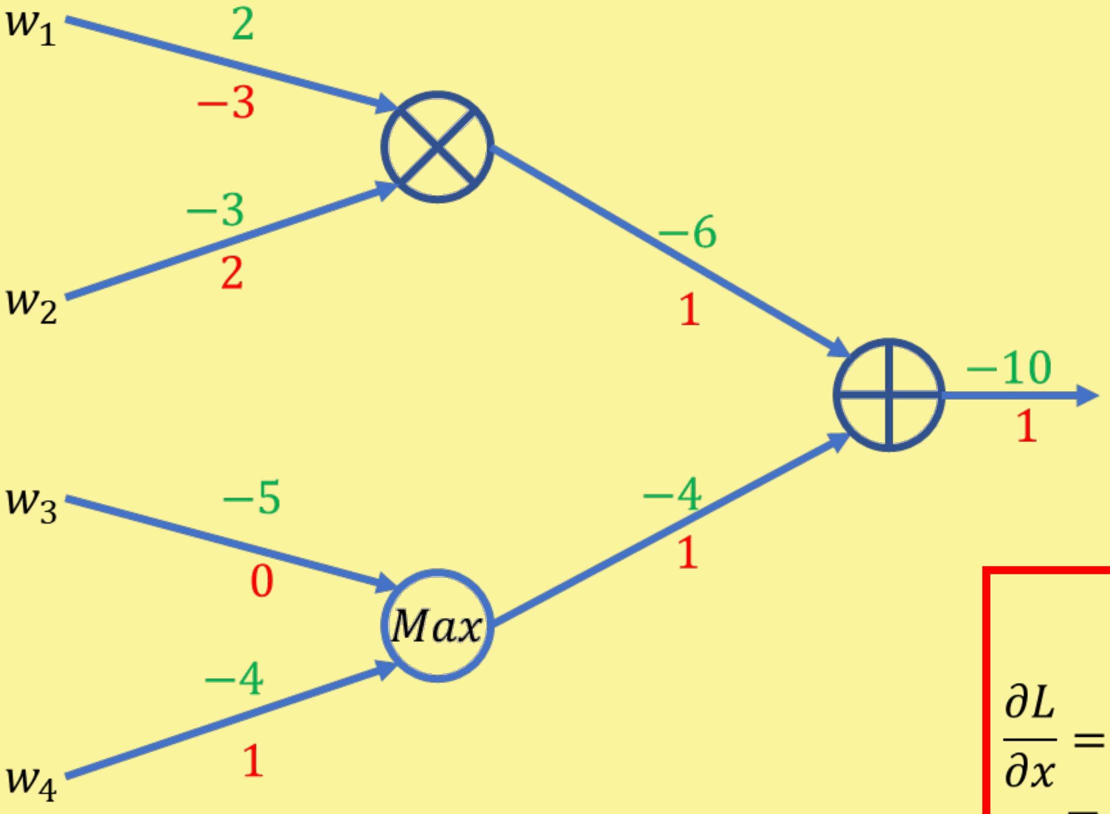
$$\frac{\partial L}{\partial x} = g \qquad \frac{\partial L}{\partial y} = g$$

$$f = x$$

$$\frac{\partial L}{\partial x} = gy \qquad \frac{\partial L}{\partial y} = gx$$

$$\frac{\partial L}{\partial f} =$$

# Another Example




$$f = x +$$

$$\frac{\partial L}{\partial x} = g \qquad \frac{\partial L}{\partial y} = g$$

$$\frac{\partial L}{\partial f} =$$

$$f = x$$

$$\frac{\partial L}{\partial x} = gy \qquad \frac{\partial L}{\partial y} = gx$$

$$f = \max(x, y)$$

$$\frac{\partial L}{\partial x} = g \; if \; x > y \qquad \frac{\partial L}{\partial y} = g \; if \; y > x$$

$$= 0 \; otherwise \qquad = 0 \; otherwise$$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Thank you