

Chapter 8

Unity if examples

Now that we can “think” with ifs, we can improve the moving, coloring, and resizing examples from before. Even if you have no interest in making games, this is a pretty good way to practice writing if’s.

Here’s the old “move across the screen” code with only x changing:

```
public float x=-7.0f;
public float xSpd=0.1f;

void Update() {
    x = x + xSpd;
    transform.position = new Vector3(x, 0, 0);
}
```

Instead of shooting past the right side, we could have it wrap around like the old Asteroids game. We just need to figure out how to say “when it goes past the right side, return to the left.”

That’s two separate things to figure out. Going to the left side is easy, we’ve done it before: `x=-7;`. You might think that can’t be right – putting `x=-7;` in `Update` will keep us glued to the left edge. But that’s the other part – how to do it only at the correct time.

Checking past the right side is `if(x>7)`. Combining them is: `if(x>7) x=-7;`. Move with wrap-around looks like this:

```
public float x=-7.0f;
public float xSpd=0.1f;

void Update() {
    x = x + xSpd;
    if(x>7) x=-7; // new wrap-around to left side
}
```

```

    transform.position = new Vector3(x, 0, 0);
}

```

That new line is pretty short. A chapter ago it would have been a really bad example – why would we want to change from 7.1 to -7? But now that little `if` does exactly what we need.

It probably looks a little “snappy”. It will look better if the pop-out and pop-in were both off the edge of the screen. Tweaking +7 and -7 could make this look really nice. The easiest way to do that is to turning them into variables. Then we can adjust them as the program runs:

```

public float x=-7.0f;
public float xSpd=0.1f;

public float xMin=-7.0f, xMax=7.0f; // the new left and right side variables

void Update() {
    x = x + xSpd;
    if(x>xMax) x=xMin; // replaced -7 and 7 with variables

    transform.position = new Vector3(x, 0, 0);
}

```

The `if` is even a little bit easier to read this way. It says what it does “if you’re past the maximum, drop down to the minimum”.

We can use the same trick to change the size. This grows from normal to double-wide then snaps back and repeats (remember 1 means normal-size):

```

public float xSz=1.0f;

void Update() {
    xSz += 0.01f;
    if(xSz>2.0f) xSz=1.0f; // wrap

    transform.localScale = new Vector3( xSz, 1, 1);
}

```

Wrapping-around color is about the same. To make it more interesting I’ll have it go down (remember color numbers are from 0 to 1):

```

public float g=1.0f; // start full green

void Update() {
    g -= 0.01f; // go down to 0
    if(g<0) g=1.0f; // wrap 0 back to 1
}

```

```

    GetComponent<Renderer>().material.color = new Color(1, g, 0);
}

```

Notice it checks for *less than 0*, since it's going down. I kept the red slot as always 1 for fun. It goes from (1,1,0) to (1,0,0), which is yellow to red (red and green makes yellow).

8.1 bouncing

The other fun thing we can do when we hit the edge is bounce. This will flip the speed when we hit the right edge:

```

public float x=-7.0f;
public float xSpd=0.1f; // <- speed is a variable, so we can change it

void Update() {
    x += xSpd;
    if(x>7) xSpd = -0.1f; // start moving left

    transform.position = new Vector3(x, 0, 0);
}

```

Again, pretty cool for just one if. It looks even cooler if you have a wall and tweak the edge so it looks like it's bouncing off it.

An improved version would bounce off both sides, and keep whatever speed it started with. If we use `xSpd *= -1` we can turn a forward speed of 0.08 (or whatever) into the same speed going backwards, then positive again when it hits the left side:

```

public float x=-7.0f;
public float xSpd=0.1f;

void Update() {
    x += xSpd;

    if(x>7) { xSpd *= -1; }
    if(x<-7) { xSpd *= -1; }

    transform.position = new Vector3(x, 0, 0);
}

```

You should be able to watch see `xSpd` flip between +0.1 and -0.1 as it moves back and forth.

There's also a cool bug. When we go past 7, it should be because we were going forward and took 1 step too far. Flipping the speed will have us step back in bounds on the next move. But if we start way off the edge, like at 12, that's not true. We'll be past 7 every time, the speed will flip back and forth and the cube will just vibrate.

Size change with bouncing works the same, except the numbers are smaller (1 to 2.) This makes a square grow to 2, then shrink back down to 1, repeating:

```
public float sz=1.0f, spd=0.005f;

void Update() {
    sz+=spd;
    if(sz>2 || sz<1) spd*=-1; // flip speed when passes min or max
    transform.localScale = new Vector3(sz, sz, 1); // x&y grow the same
}
```

For fun, we can rewrite our movement bouncing using a different plan. We can have a variable `dir`, will be always be +1 or -1 for the direction we want to move:

```
public float x=-7.0f;
public float xSpd=0.1f; // always positive
public int dir=+1; // +1 is right, -1 is left

void Update() {
    if(dir==1) { // we're going right:
        x += xSpd; // add the speed
        if(x>7) dir=-1;
    }
    else { // we're going left:
        x -= xSpd; // subtracting the speed
        if(x<-7) dir=+1;
    }

    transform.position = new Vector3(x, 0, 0);
}
```

That's not quite as nice, but it fixes the off-edge bug, and it's got a nested `if`.

8.1.1 Speed increase

In older movement examples, I had the speed get faster and faster without limit. Now we can use an `if` to add a limit. Or to reset the speed, or whatever else can can think of.

I'll go back to the simple wrap-around Cube. This starts slow and speeds up. The new part is a maximum speed, using a simple `if`:

```
// wrap-around, increasing speed, to a maximum:
public float x=-7.0f, xSpd=0; // speed _starts_ at 0

void Update() {
    x = x + xSpd;
    if(x>7) x=-7; // wrap-around

    xSpd += 0.001f; // very slow speed increase
    if(xSpd>0.8f) xSpd = 0.8f; // speed limit

    transform.position = new Vector3(x, 0, 0);
}
```

Once it reaches a cruising speed of 0.8, it's only a simple wrap-around.

We could just as easily have it slow down to a minimum. We'd start `xSpd` high, subtract a tiny bit, and use a "can't get below this" `if`:

```
xSpd += -0.001f; // a little slower
if(xSpd<0.05f) xSpd = 0.05f; // lowest speed limit
```

If we copied these over the old lines, it would move quickly, but eventually settle to be a simple, slow wrap-around.

You might remember the trick where I started the speed negative and always increased it. The Cube went backwards, slowed and then reversed direction. If we do that for `y`, it's like we're making gravity – a ball going up, slowing, then falling. We may as well also add a bounce off the floor:

```
public float y=3.0f; // nearer the top, giving it room to fall
public float ySpd=0; // any speed is fine, but 0=not moving seems obvious

void Update() {
    y+=ySpd;
    ySpd -= 0.003f; // gravity

    // bounce off bottom:
    if(y<-3) {
        ySpd*=-1; // bounce up by flipping speed
        y=-3; // just in case, don't let it fall below the floor
    }

    transform.position = new Vector3(0, y, 0);
}
```

We've seen a bounce, and we've seen the slow-down-then-change-direction trick. But combined they look pretty cool – like a real ball bouncing.

Gravity and bouncing off the floor looks even cooler if we add the old *x* movement, bouncing off the sides. This cube will bounce in realistic-looking arcs:

```
public float x=2.0f, y=3.0f; // set these to anywhere interesting
public float xSpd=0.1f; // always goes this fast, left or right
public float ySpd=0.1f; // a little bit up, for fun

void Update() {
    x += xSpd; y+=ySpd;
    ySpd -= 0.003f; // gravity

    // bounce off left, right and bottom:
    if(x>7 || x<-7) xSpd*=-1;
    if(y<-3) { ySpd*=-1; y=-3; } // bounce off bottom

    transform.position = new Vector3(x, y, 0);
}
```

It's just a few simple tricks, combined, but it should look a lot like a ball bouncing around in a box.

We can try a resetting speed increase using color. The code below starts with the yellow-to-red code. But it makes green go faster and faster, then resets it to change slowly again:

```
public float g=1.0f, gSpd=-0.01f; // green, green speed change

void Update() {
    g += gSpd; // green goes down
    if(g<0) g=1.0f; // wrap around back to 1

    gSpd-=0.0005f; // the speed change increases
    if(gSpd<-0.03f) gSpd=-0.01; // reset to starting speed when too fast

    GetComponent<Renderer>().material.color = new Color(1, g, 0);
}
```

Hopefully this isn't too bad. It's a simple wrap-around, except going down, not up. Then another wrap-around for the speed. Then we had to figure out good numbers for the speed. 0.0005 seems too small, but we're only going from 1 to 0, and the frames happen quickly.

Even so, it's easy for a few simple tricks, combined, to start to look confusing.

8.2 Counting

We can do some interesting things if we count how many laps the cube makes. Making a lap counter is easy. Make an int variable, and add 1 on each reset:

```
// partial code for a lap counter:
public int laps=0;

void Update() {
    x += xSpd;
    if(x>7) {
        x=-7;
        laps=laps+1;
        // do special lap stuff here
    }
}
```

If we watch in the Inspector, laps will go up each time, but nothing else interesting will happen.

The next part is using the counter to do something. I'd like it to turn red after 3 laps, and green after 7 laps, then back to white on lap 8. All of that goes in the "do special lap stuff here" area:

```
// change color after laps 3, 7 and 8:
public float x=-7.0f, xSpd=0.1f;
public int laps=0;

void Update() {
    x += xSpd;

    if(x>7) {
        x=-7;
        laps += 1;

        // color change checks:
        if(laps==3)
            GetComponent<Renderer>().material.color = new Color(1,0,0); // red
        if(laps==7)
            GetComponent<Renderer>().material.color = new Color(0,1,0); // green
        if(laps==8)
            GetComponent<Renderer>().material.color = new Color(1,1,1); // white
    }

    transform.position = new Vector3(x, 0, 0);
}
```

This is probably the largest body of an `if` we've had yet. But I think it seems natural. When you get past the end you should: 1) wrap around, 2) count the lap, and 3) use `ifs` to check for the three special laps.

The color-changing `if`'s are a little new, but not really. We've used the line to change color before, just never guarded by an `if`.

A possibly confusing thing about this is what color is the 4th lap? The code doesn't say. Of course it's red since we turn it red on 3 and stays that way until we change it again. Another confusion is I said it resets after the 8th lap, but the code simply turns it white. That's because there's no "reset" command. Since it started out as white, turning it white feels like a reset.

A little trickier use of a lap counter, we can do something every 3rd lap, using modulo. `laps%3` (the remainder after dividing by 3,) will be 1,2,0,1,2,0 ... after each lap. So `(laps%3==0)` is true every 3rd lap.

This sets the speed to "slow", every third lap:

```
if(x>7) {
    x=-7;
    laps++;

    // set speed for next lap:
    if(laps%3==0) xSpd=0.03f; // slow
    else xSpd=0.1f; // otherwise normal speed
}
```

This sets us to slow at the end of lap 3, meaning that lap 4 is slow (and laps 7, 10, 13 and so on). That's still every 3rd lap, so fine. We could adjust the test to `if(laps%3==2)` if we absolutely needed lap 3 to be the slow one.

8.3 Delay counter

If we want to wait for a second or two, we can do that with an `int` counter, an `if` and a plan.

The simplest plan is having the counter be how many Updates we should skip, count down, and zero means we're done waiting. If we want to wait for 60 Updates (about a second,) we set the counter to 60.

This moves a Cube in big steps, with an 80 update delay in-between each move. It should hop from left to right:

```
public float x=-7.0f;
public int delayCounter=0; // how many Updates to skip

void Update() {
```

```

if(delayCounter>0) { // still waiting:
    delayCounter -= 1;
}
else {
    x = x + 1; // one big step
    transform.position = new Vector3(x, 0, 0);

    delayCounter=80; // wait for one more second
}
}

```

The movement code is now guarded by an `if`. That's what `if`'s do – they say that we *might* do something. An `if-else` is good for this: either we're waiting on the countdown, or we're not. You could watch `delayCounter` spin down to 0 (the true part of the `if` is running,) then see the Cube pop forward and the counter reset (the `else` ran one time.)

When the delay ends, we don't have to restart it right away. This version moves smoothly with a wrap-around, using the delay only when we hit the edge (it waits a little bit before moving across again):

```

public float x=-7.0f;

public int delayCounter=0; // how many Updates to skip

void Update() {
    if(delayCounter>0) { // still waiting:
        delayCounter--; // subtract 1 shortcut
    }
    else {
        x += 0.1f; // standard small move
        if(x>7) { // wrap and signal for a pause:
            x=-7;
            delayCounter=80;
        }
        transform.position = new Vector3(x, 0, 0);
    }
}
}

```

Essentially, `delayCounter` is there for us whenever we need it. We want to delay after a lap, so we set `delayCounter`. The it takes care of making it actually delay us.

It might look funny having delay come first in the `if`. We can flip the order to put moving first and waiting last:

```

if(delayCounter<=0) { // not waiting

```

```

    x+=0.1f;
    if(x>7) {
        x=-7;
        delayCounter=80;
    }
    transform.position = new Vector3(x, 0, 0);
} // end of movement
else delayCounter--;
}

```

This next example uses a delay with a size change. The basic code makes the Cube be size 1, 2, 3, 4 then back to 1. A delay counter makes it do that once every second. We should see it gradually pop larger:

```

public float sz=1.0f;
public int delay=0;

void Update() {
    if(delay>0) delay--;
    else {
        // sz goes 1,2,3,4 then back to 1:
        sz+=1;
        if(sz>4) { sz=1; delay=120; }
        else delay=60;

        transform.localScale = new Vector3(sz,sz,sz); // all-around larger
    }
}

```

Notice how I got tricky with setting the delay. When it wraps around to 1 I give a longer 120-tick delay.

We could write the 60 or 120 delay a different way: always give a delay of 60, with an extra 60 for a wrap-around:

```

    if(delay>0) delay--;
    else {
        sz+=1;
        delay=60; // base delay
        if(sz>4) { sz=1; delay+=60; } // extra delay for wrapping

        transform.localScale = new Vector3(sz,sz,sz); // all-around larger
    }
}

```

What I like about this is the best way depends on how you think about it. Maybe you feel like it's two different delay times. Or maybe it makes more sense

as a base delay with extra for wrapping.

Finally, I mentioned counting down was the simplest plan for a delay. Another plan would be counting up to the total. We'd need an extra variable. To wait for 20 Updates we'd set the total to 20 and the counter to 0. Here it is with the movement wrap-around:

```
int x=-7;

int delayCount=0; // during a delay this counts up to the total, from 0
int delayTotal=0; // no delay right now

void Update() {
    if(delayCount<delayTotal) // delayCount goes up, delayTotal stays the same
        delayCount++;
    else {
        x+=0.1f;
        if(x>7) {
            x=-7;
            delayTotal=80; // how long to wait
            delayCount=0; // reset the count
        }
        transform.position = new Vector3(x, 0, 0);
    }
}
```

This is more complicated, which usually means worse. But a possible advantage is if you want to show the delay as a percent – like one of those bars that fills in. It would be $1.0f * \text{delayCount} / \text{delayTotal}$. We can't compute that with a single count-down, since we don't save where it started.

8.4 State variables

In the second version of bouncing, with `dir`, my idea was the program has two stages – moving right and moving left. `dir`'s job was to remember which stage we were on. I used -1 and +1 as easy-to-remember values, but it could have been 1=left and 2=right.

Sometimes we have a program with more complicated stages, and we formalize the idea of a stage variable. Here's the whole trick:

Draw out a picture with your stages and the rules for going to the next. Number them – the exact numbers don't matter; the numbers are like their names.

To program it, make an `int` to remember which stage you're on. Inside, use a big “do only one of these” cascading if-else-if-else. Make one part for each

stage. Whenever you want to go to a stage, like stage 3, write `stage=3`

Here's an example. The comments under `stage` explain what it does:

```
public int stage=0;
// stage 0 = move right fast until we get to x=6
// stage 1 = grow until we get to size 2
// stage 2 = slowly move up to y=4
// stage 3+ = done, do nothing

float x=-7, y=0; // position, for stage 0 and 2
float sz=1.0f; // Cube size, for stage 1

void Update() {
    if(stage==0) { // move right until past 6
        x += 0.1f;
        if(x>=6) stage=1; // done moving right
    }
    else if(stage==1) { // grow until size 2
        sz += 0.02f;
        if(sz>=2.0f) stage=2; // done growing
    }
    else if(stage==2) { // move up until past 4
        y += 0.03f;
        if(y>=4) stage=3; // done going up
    }
    else if(stage==3) {} // stage 3 is do nothing

    // simpler to do these always, even if some stages don't need them:
    transform.position = new Vector3(x, y, 0);
    transform.localScale = new Vector3(1, sz, 1);
}
```

The trick is it only does one part each Update. For stage 0 it only runs those two lines: move a little right, past 6 means done – set `stage` to 1. Then, starting on the *next* Update, run only the two lines for stage 1. `stage` is the control for what Update does.

This one changes color in stages, using a delay counter so it's not a blur. Also, instead of stopping at the last stage, it repeats to stage 0:

```
int colStage=0;
// 0 = red for a long time
// 1 = bright blue quickly
// 2 = yellow for a medium time, then back to 0
```

```

int delay=100; // wait a little before starting, for no reason

void Update() {
    // whole thing is in a basic delay if-else:
    if(delay>0) delayCount--; // delayed: count down and wait
    else {
        // state machine ifs:
        if(colStage==0) {
            // red
            GetComponent<Renderer>().material.color = new Color(1,0,0);
            delay=150;
            colStage=1;
        }
        else if(colStage==1) {
            // bright blue:
            GetComponent<Renderer>().material.color = new Color(0.5f,0.5f,1);
            delay=30;
            colStage=2;
        }
        else if(colStage==2) {
            // yellow
            GetComponent<Renderer>().material.color = new Color(1,1,0);
            delay=70;
            colStage=0; // back to red
        }
    }
}
}

```

This spends almost all of it's time subtracting from `delay`. Each stage runs for only one update: it changes color, sets the new delay, and goes to the next stage (for when the delay is finally over.)

The important thing is how we're still using our extra made-up `stage` variable to remember which step we're on.

Not really important for these examples, but the official name for this sort of thinking is a **State Machine**. You can find state diagrams (circles with arrows,) or GUI's (Unity's built-in Mechanim animation system is a drag&drop state machine.)

For fun, why wouldn't we use a word for the state, making it easier to read? Here's what that would look like:

```

public string stage="move right";
// will be "move right" "grow" "move up" or "done"

...

```

```
if(stage=="move right") {
  x+=0.1f; if(x>=6) stage="grow";
}
else if(stage=="grow") {
  sz+=0.02f; if(sz>=2.0f) stage="move up";
}
else if(stage=="move up") {
  y+=0.03f; if(y>=4) stage="done";
}
```

It's easier to read, but it's so easy to make a mistake. If we wrote "go up" or "Move up" (capital M) the code would stall, with no errors. It turns out that using strings to control what happens almost always causes hard-to-spot bugs. Later we'll see a trick to make the numbers easier to read in a safer way.