**M1 – Persistence of Vision**

Persistence of vision is a side-effect of human vision that allows animation to work.  
When the eye sees something, the light passes through the Cornea (the lens on the front of the eye), through the pupil, and is focused onto the retina – a patch of cells at the back of the eye that react to light and send nerve impulses to the brain, which we interpret as sight.  
Because the retinas use chemical reactions, sight is not instantaneous. It takes a few milliseconds for the retina to convert the light to nerve impulses, travel to the brain, and then another 80 milliseconds for the brain to interpret the image.  
This delay results in something called ‘persistence of vision’. Essentially, when the light entering the eye changes, the brain takes a while to catch up, resulting in seeing an out-of-date image for short while. This effect is why you can see spots after a bright flash of light – the cells in the retina adjust slowly to the changing light.  
This effect is used in film and animation to create the illusion of movement. When a rapid sequence of images is shown to a viewer, the brain can’t detect the pauses in-between each image and assumes it is natural movement.  
The minimum rate at which images must be shown to create this effect is 24 times per second. At this framerate (frames per second), we see movement very similar to what we see in real life. Fast-moving objects blur the same way they do in real life.  
At lower framerates, the brain can see that the animation is a sequence of images, and this results in choppy, jerky motion. At very low framerates (15-), viewers just see still images.  
While 24 FPS is the industry standard for film and animation because of its natural look, sometimes higher framerates are also used.  
On the internet, 30FPS is the standard for video, and can be seen on sites such as YouTube, Vimeo and VideoJug. The reason for this is that the internet video is less concerned with bandwidth and standardization than, say, TV or cinema is, and it is easier to do maths for a round number such as 30 rather than an unusual one like 24.  
Once computers and infrastructure developed enough to be able to handle it, 60FPS became commonplace, particularly on YouTube (which allows playback of the same video at different framerates). 60FPS is also considered a minimum standard for games, as it results in very fluid, smooth looking movement. It is not used in TV or cinema, partially to reduce costs and keep filesizes down, but also because 60FPS looks ‘faster’ than real life. In test screenings of 60FPS movies, audiences complained that it looked unnatural.  
In animation, there are four main standards – 24FPS, 30FPS, 60FPS and variable framerate.  
24 FPS comes from the standard of TV and cinema, while 30FPS started with digital animation. 60FPS is used in games, and animations that require little motion blur, such as a slow-motion action scene.  
Often animators will use a variable framerate. In this case, the framerate changes depending on what is happening in the animation. Fast-paced action scenes and panning shots will often be 30FPS, but static shots or simpler animations may be as low as 8FPS.  
The most extreme example of this is in anime, a style of Japanese animation. Action scenes will often have high framerates and a detailed art style, but the rest of the time will use a very low framerate and simpler art style to simplify the production.  
The only animation that goes higher than 60FPS is video games. 60 is considered the minimum standard because it matches the refresh rate of most screens – 60Hz.  
However, on monitors with higher refresh rates (which can go as high as 220Hz), a framerate closer to the refresh rate will look better to the viewer.  
The reason for differing framerates in different media is because the eye does not have a fixed framerate or refresh rate. Instead, the eye takes in light continuously and different parts react at different speeds. The centre of the retina, called the fovea, is responsible for the middle 2° of the field of view. This area sees in the most detail, but is also the slowest.  
Around that, there is a section that sees at a much lower resolution, but is more sensitive to movement and light.  
At the peripherals of human vision, the retina only sees in black and white (the brain fills in colour), but is extremely sensitive to light and movement.  
While the fovea interprets 24Hz as movement, the middle section can detect still frames up to around 50Hz. It is not known how well the peripheral vision sees movement – some experts claim up to 300Hz.