

Math: Calculating Single File Sizes

Objective:

Learn how to calculate the file size of a Video Project to determine if the costs of the project will fall within budget guidelines.

***Teacher Note: Use the following information for class instruction or make copies for students to keep in their folders. Use this information so students can do the following:**

1. Calculate an assortment of file sizes
2. Understand how file sizes change with content and distribution method.
3. Demonstrate knowledge of why file data is manipulated
4. Demonstrate proficiency with math calculations
5. Learn industry standard aspect ratios, terms and formulas

Everyone who creates content that will be broadcast, streamed, downloaded or shared must be aware of the file size of the project. Productions that are too big won't play quickly, won't load quickly, and will take up bandwidth and server storage space. Productions compressed to smaller file sizes will pixelate and will suffer from poor quality.

For the Audio Video Production Companies, file size (video quality) is determined by the client and distribution method. For Broadcast Companies, a smaller file size (lower video quality) is often preferred in order to maximize storage capacity and bandwidth of their network.

In this math section you will learn to roughly figure out the file sizes of images so that you can adjust them for quality and speed of reproduction and so when you upload to an internet video site and it says your video is too big, you can make an informed decision on whether to adjust DPI, aspect ratio, etc.

Example:

Let's start with a standard video application screen stage or canvas that is 720 x 480 pixels in size. The DPI is 72 and the bit depth is 24 bits RGB (16.7 million colors).

This produces a file that is 345,600 total pixels in size and is 10 inches x 6.66 inches in print size. There are 1,036,800 bytes, 1012.5 kilobytes (kb) and .9887 Megabytes (Mb) in the file. Some applications will tell you all of this information, but others will not. You can calculate this by yourself so it is not a mystery how the computer comes up with these numbers.

Let's look at how this information is figured out

Total pixels is an easy math problem. It is simply the total pixels of any size area (length x width = area).

$L \times W = \text{Area}$

SD Video - 720 px x 480 px = 345,600 total pixels

HD Video – 1920px x 1080px = 2,073,600 total pixels (sometime called 2K resolution)

To convert pixels to inches you need to know that there are 72 pixels per inch. The formula to convert pixels to inches is $X/72=\text{inches}$, where X is the number of pixels on a side.

$$720\text{px}/72 = 10 \text{ inches}$$

$$480\text{px}/72= 6.6666 \text{ inches}$$

$$1920\text{px}/72 = 26. 6666 \text{ inches}$$

$$1080\text{px}/72 = 15 \text{ inches}$$

So once you figure out the size of your bitmap, how can you convert it to a data file size?

There are several formulas for the number of bytes of data each pixel holds, but the average we will use here is 3, which is the norm for RGB color.

The formula for figuring out the number of bytes in an image is $L \times W \times 3 = \text{Bytes}$, where the length and width are measured in pixels.

$$\text{SD} - 720\text{px} \times 480\text{px} \times 3 = 1,036,800 \text{ bytes (of information)}$$

$$\text{HD} - 1920\text{px} \times 1080\text{px} \times 3 = 6,220,800 \text{ bytes (of information)}$$

Now how do we convert that to kilobytes or megabytes?

Back in the early computer days, when data cost so much to process and store and we managed data in kilobytes, the standard was set to binary kilobytes. Memory chips and file sizes are kilobytes (1024 bytes) or megabytes (1024x1024 bytes) or gigabytes (1024x1024x1024 bytes). Yes, it really doesn't matter to us today if we have some extra kb's in storage when we're measuring our storage in gigs, but it still matters when you're saving tens of thousands of images to be used in a game, animation or video. Even today we still need to keep our file sizes as small as possible.

To convert our photograph to kilobytes we divide by 1024.

To convert to megabytes we divide by 1,048,576 (1024 x 1024)

For gigabytes we divide by 1024 cubed (1024 x 1024 x 1024).

$$1,036,800 / 1024 = 1,012.5 \text{ kilobytes (kb)}$$

$$1,036,800 / (1024 \times 1024) = .9887695 \text{ megabytes (Mb)}$$

$$1,036,800/ (1024 \times 1024 \times 1024) = .0009655 \text{ gigabytes (GB)}$$

Name _____

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Calculating Single Image File Sizes

Practice Formulas:

Total pixels $L \times W = \text{Area}$

To convert pixels to inches, 72 pixels per inch with $X/72 = \text{inches}$, where X is the number of pixels on a side.

Number of bytes of data in an RGB pixel = 3

The formula for figuring out the number of bytes in an image is Length in Pixels x Width in Pixels x 3 = Bytes

To convert our photograph to kilobytes we divide by 1024. **To convert to megabytes** we divide by 1,048,576 (1024 x 1024) and **to gigabytes** we divide by 1024 cubed (1024 x 1024 x 1024).

1. You have an analog photograph that measures 8" x 10".
If you scan the photo at 72 DPI and keep it 8" x 10" what would the kilobyte file size be?
Megabytes?
2. If you take the same photo in question 1 and scan the photo at 72 DPI and reduce the size to 5" x 7", what would the file size be in kilobytes? Megabytes?
3. You have a digital file that is 1080 pixels by 500 pixels. What is the size in inches?
4. Your 10-second video contains individual images at a resolution of 720 pixels x 480 pixels at 72DPI. Your frame rate is 30 frames per second. How many images will be needed for the movie? What is the size of each image? What is the size of the total movie in bytes?
Kilobytes? Megabytes?

Calculating Video and Audio File Sizes

Student Notes: (Keep a copy in your folder)

To calculate file size for a movie you will need to first calculate the size of the video portion of the movie. We will then calculate the audio portion of the video and add them together for a total movie size. Understand for this lesson we are using UNCOMPRESSED values for both the Audio and Video. Compression Algorithms, such as MP4, MP2 and H.264 employ different variables when compressing a movie. These algorithms are complex and can be difficult to accurately calculate file size using the methods we are teaching. Uncompressed file sizes will be larger than compressed files.

CALCULATING VIDEO FILE SIZE

- The Duration of the Video in Time (may need to convert to seconds)
- How many Frames per Second (fps) Today’s cameras allow the user to select several frame rates.
- The amount of Horizontal Pixels. (SD Video = 720 HD Video = 1080 or 1920)
- The amount of Vertical Pixels. (SD Video = 480 HD Video = 720 or 1080)
- Bit Depth of the image – the number of bits per pixel. More pixels = More Color

Example Video is shot in 720x1080 HD, 36 seconds in duration at 24 fps and a bit depth of 8-bit
 Audio is Stereo 48K at 16bit

Formulas:

Step 1. Total # of Frames = Frame Rate x Duration of Video in Seconds

Example: The above example Video has a duration of 36 second and shot at 24 fps
 $24\text{fps} \times 36\text{sec} = 864 \text{ frames}$

Step 2. File Size of the Frame = Horizontal Pixels x Vertical Pixels x Bit Depth / 8 x 1024

Example: The above example Video is formatted at HD 720 x 1080 at a bit depth of 24.

$$\frac{1080H \times 720V \times 8}{8 \times 1024} = \frac{6,220,800}{8192} = 759.375 \text{ KB}$$

Step 3. Total VIDEO File Size = Total # of Frames x File Size of the Frame

Example: The above example final step.
 $864 \text{ frames} \times 759.357 \text{ KB} = 656,084.448\text{KB}$ or 640.707MB

CALCULATING AUDIO FILE SIZE

Required Information

- The Duration of the Audio File in Time (may need to convert to seconds)
- Sample Rate: The number of times a sample is taken from the sound wave per second. CD audio is 44100 or 44.1K. Many video cameras and editors use 48K
- Sample Size (bit resolution): Number of bits per sample. The most common are 8-bit, 16-bit and new 32-bit

Example Video is shot in 720x1080 HD, 36 seconds in duration at 24 fps and a bit depth of 8-bit
 Audio is Stereo 48KHz at 16bit

Mono Audio File Size = Sample Rate x Sample Size x Time

Stereo Audio File Size = (Sample Rate x Sample Size x Time) x 2

Step 4. Total AUDIO File Size = Stereo Audio File Size = (Sample Rate x Sample Size x Time) x 2

$$(48,000\text{Hz} \times 16 \text{ bits} \times 36 \text{ seconds}) \times 2 = 27,648,000 \text{ bits}$$
$$\frac{27,648,000}{8} = 3,456,000 \text{ Bytes} \qquad \frac{3,456,000}{1024} = 3,375 \text{ KB} \qquad \frac{3,375}{1024} = 3.29 \text{ MB}$$

Notice we added some conversion steps to get the value to where we can add it to our video file size. We converted bits to Bytes by dividing by 8: We converted Bytes to Kilobytes by Dividing by 1024: we converted Kilobyte to Megabytes by again dividing by 1024. Final Answer is 3.29MB

Step 5. Video File Size + Audio File Size = Total Video File Size

$$(\text{Video File Size}) 640.707\text{MB} + (\text{Audio File Size}) 3.29\text{MB} = (\text{Total File Size}) 643.997\text{MB}$$

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Calculating Video and Audio File Sizes: Practice

PROBLEM 1: Calculate the file size for a Video with NO AUDIO. The Video is 1 minute and 45 seconds long. It was shot in uncompressed 10-bit Full HD format 1920 x 1080 at 30 fps.

PROBLEM 2: Calculate the file size for an AUDIO VOICE OVER. The audio is in Mono at a sample rate of 48Khz and a bit rate of 16. Voice over run time is 2 minutes 38 seconds

PROBLEM 3: Calculate the Total File Size For a Movie: Run time 1hr:29min:16sec. The movie is HD 1080 x 720 uncompressed 8-bit video at 24frames per second. Audio is 8-bit at 44.1Khz Stereo.

PROBLEM 4: Calculate the Total File Size for a Video Clip. It was shot with one of the new 4K cameras. Run time is 48 seconds. It is 10-bit uncompressed raw video at a resolution of 1920 x 1920 at 60fps. Audio is 32-bit mono at 96Khz.

Calculating Production Costs

Objective:

Calculate the cost of an Audio Video Project and determine how much it will cost a small business to produce the video.

The Scenario:

Sam is a new startup video production company. His new production company has limited equipment and resources. However, he has built a reputation for creating quality work and is on the verge of growing his business.

Sam has been asked to provide a proposal to a local municipality for an informational video on Trash Collection. The video is to air on the local municipality cable TV channel. The video must be produced to broadcast standards. Sam will be responsible for shooting and editing the video **only**. All Pre-production requirements such as script, storyboards and permissions will be the responsibility of the municipality. He has been given guidelines stating that he will have only 5 full workdays to shoot the required video and 10 days to edit and complete the project. These days are consecutive and not concurrent. In other words, 15 days total to complete the project. Do not include weekends.

GOAL:

Sam needs to determine what his actual production costs are going to be to his business for this specific project. These are the costs that he must incur and manage before the municipality pays the bill. He must decide if his small businesses budget can facilitate production costs associated with this project.

Problem 1: Figure out equipment needs and how much it will cost to rent all the equipment

Sam needs to rent the following equipment in order to meet the Broadcast Standard specified by the municipality cable TV Station. Sam will lease the Camera for 6 days. I needs one day to get familiar with its operation. He will lease the tripod and dolly, pro light kits, boom mic with pole and C stands with sand bags for 5 days. He will lease the Non-Linear Computer Editing Station for 12- days, also to become familiar with its operation. Rental Company 2 offers a 10% discount if you rent the equipment by the week instead of by the day. A week rental (7 days with the equipment) is defined as 5 individual Day Rates. Day Rate Price is for individual Items.

Equipment Needed	Rental Company 1 (DAY RATE)	Rental Company 2 (DAY RATE)
1-Broadcast Quality Video Camera	\$340.00	\$365.00
1- Pro Tripod and Dolly	\$210.00	\$195.00
2- Pro Light Kits	\$107.00 ea.	\$112.00 ea.
1 – Boom Mic and Pole	\$96.00	\$100.00
4 – C stands with sand bags	\$ 19.00 ea.	\$23.00 ea.
1 – Non-Linear Computer Editing Station	\$495.00	\$575.00

How much is Sam's Rental costs from Rental Company 1?

How much is Sam's Rental costs from Rental Company 2?

How much is Sam's Rental costs from Rental Company 2 if he utilizes the 10% discount for weekly rentals?

Which Company provides Sam with the best deal and why? What is his final rental cost?

Problem 2: Figure what his labor costs will be based on the schedule that the municipality has provided – Sam will need help to shoot and edit the video. He employs 1- Video Assistant at \$8.75 per hour and 1-Audio Assistant at \$7.85 per hour. Sam is required to pay 3.25% payroll tax (employer contribution) and 1.25% unemployment tax on both employees. Sam needs to earn \$25.00 an hour and pays 6.50% in payroll tax and 0% in unemployment tax. Sam will use both employees for the 5-day video shoot. Sam will use the Video Assistant for 7- of the 10 editing days and the Audio Assistant for 4 of the 10 editing days. Sam will work all 15 days of the project.

What is the total Labor cost for the Video Assistant?

What is the total Labor cost for the Audio Assistant?

What is the total Labor cost for Sam?

How much total does Sam pay the government in payroll taxes?

How much total does Sam pay for unemployment tax?

What is Sam's Total labor cost for this project?

Problem 3: How much will it cost Sam's company to produce the Trash Video for the municipality?