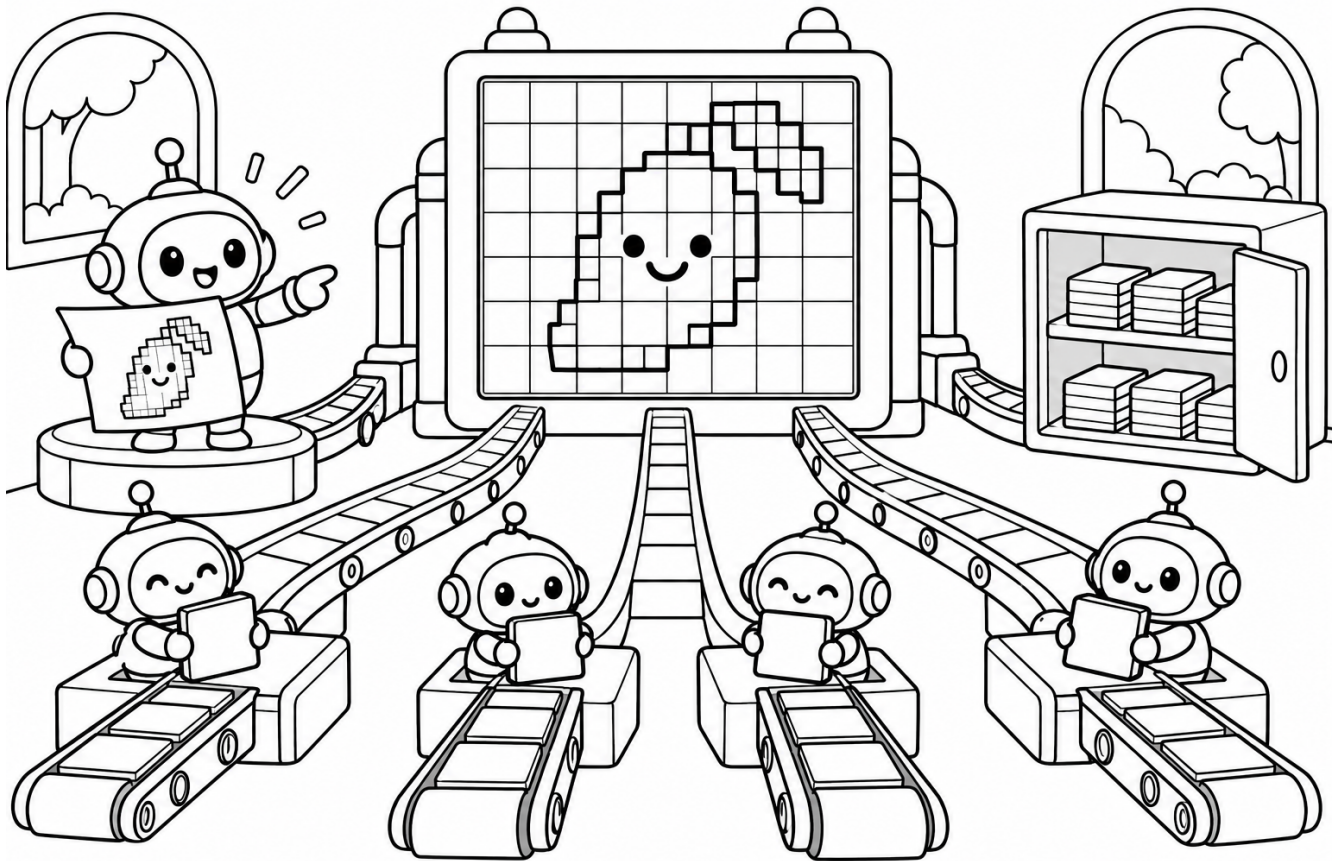


GPU Pixel Factory

A screen-free computer engineering adventure.



20 activities | Ages 6-9 with support

YOU NEED

A pencil, one dark crayon, child-safe scissors, glue or tape, and this pack. No computer or color printer needed.

CHOOSE A MISSION

Pictures: 1-6. Build: 7-9.

Factory: 10-18. Create: 19-20.

Try 2-4 activities per sitting. Read aloud as needed.

Print single-sided: activity 7 includes cut-out pieces.

This is a simplified paper model. CPUs also work in parallel. Model rounds are not computer seconds.

A picture's journey

Connect each step to its job. Then number the steps from 1 to 4.

INPUT



A

The computer follows the instructions.

INSTRUCTIONS



B

You tap a button to ask for a picture.

PROCESSING



C

The finished picture appears on a display.

OUTPUT



D

A program says what the computer should do.

Draw one kind of input you use.

This shows one possible picture-making journey. Real computers have many more steps.

Meet the computer crew

Write the correct crew name in each job box.

WORD BANK: CPU / GPU / MEMORY / DISPLAY

A

Runs many kinds of program instructions.

B

Is well suited to many similar picture calculations.

C

Holds data and instructions while they are needed.

D

Shows the finished picture to you.

Which two crew members do calculations?

CPU = central processing unit. GPU = graphics processing unit. Both can do parallel work.

Decode a hidden picture

For each row, fill squares marked 1. Leave squares marked 0 white.

ROW INSTRUCTIONS

1: 0 1 1 0 0 1 1 0

2: 1 1 1 1 1 1 1 1

3: 1 1 1 1 1 1 1 1

4: 0 1 1 1 1 1 1 0

5: 0 0 1 1 1 1 0 0

6: 0 0 0 1 1 0 0 0

7: 0 0 0 0 0 0 0 0

8: 0 0 0 0 0 0 0 0

	1	2	3	4	5	6	7	8
1								
2								
3								
4								
5								
6								
7								
8								

Each little square is a pixel in our paper picture.

What shape appeared?

A digital image can store pixel information as numbers. This model uses only black and white.

Encode your own icon

Draw a black-and-white picture. Write its rows as 1s and 0s.

	1	2	3	4	5	6	7	8
1								
2								
3								
4								
5								
6								
7								
8								

YOUR CODE

1: _____

2: _____

3: _____

4: _____

5: _____

6: _____

7: _____

8: _____

Give only your code to a partner. They can copy the empty grid on spare paper and decode it.

Did their picture match? If not, check row:

1 means fill. 0 means leave white. Keep exactly eight digits in every row.

Coordinates at work

Use the row list to fill a six-by-six grid. Rows run from top to bottom.

Row 1: column 3

Row 2: columns 2, 3

Row 3: columns 1-6

Row 4: columns 1-6

Row 5: columns 2, 3

Row 6: column 3

	1	2	3	4	5	6
1						
2						
3						
4						
5						
6						

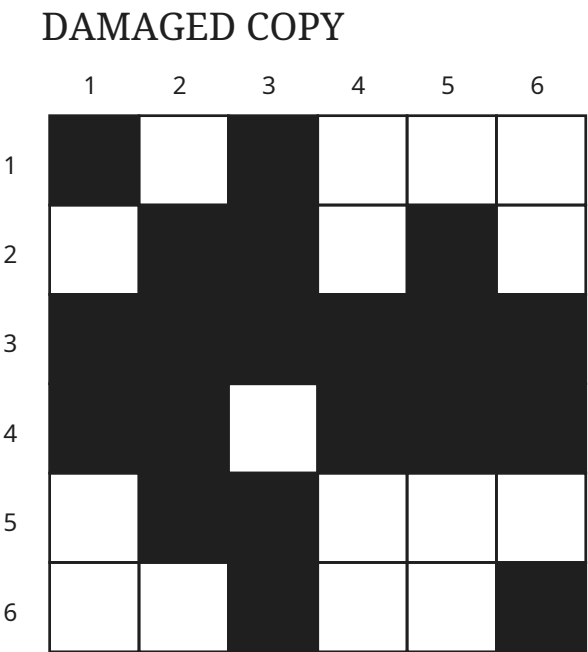
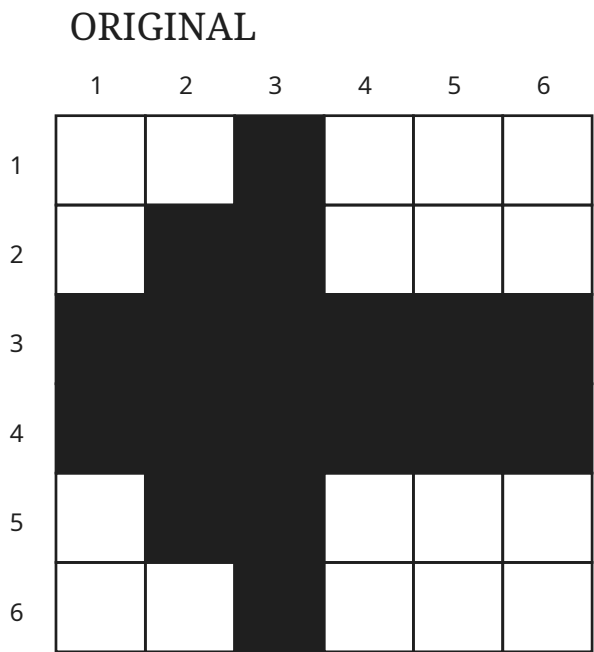
Which way does the finished arrow point?

How many pixels did you fill?

Coordinates give every pixel an address. This pack always writes row first, then column.

Repair four pixels

Compare the pictures. Circle all four changed pixels on the right.



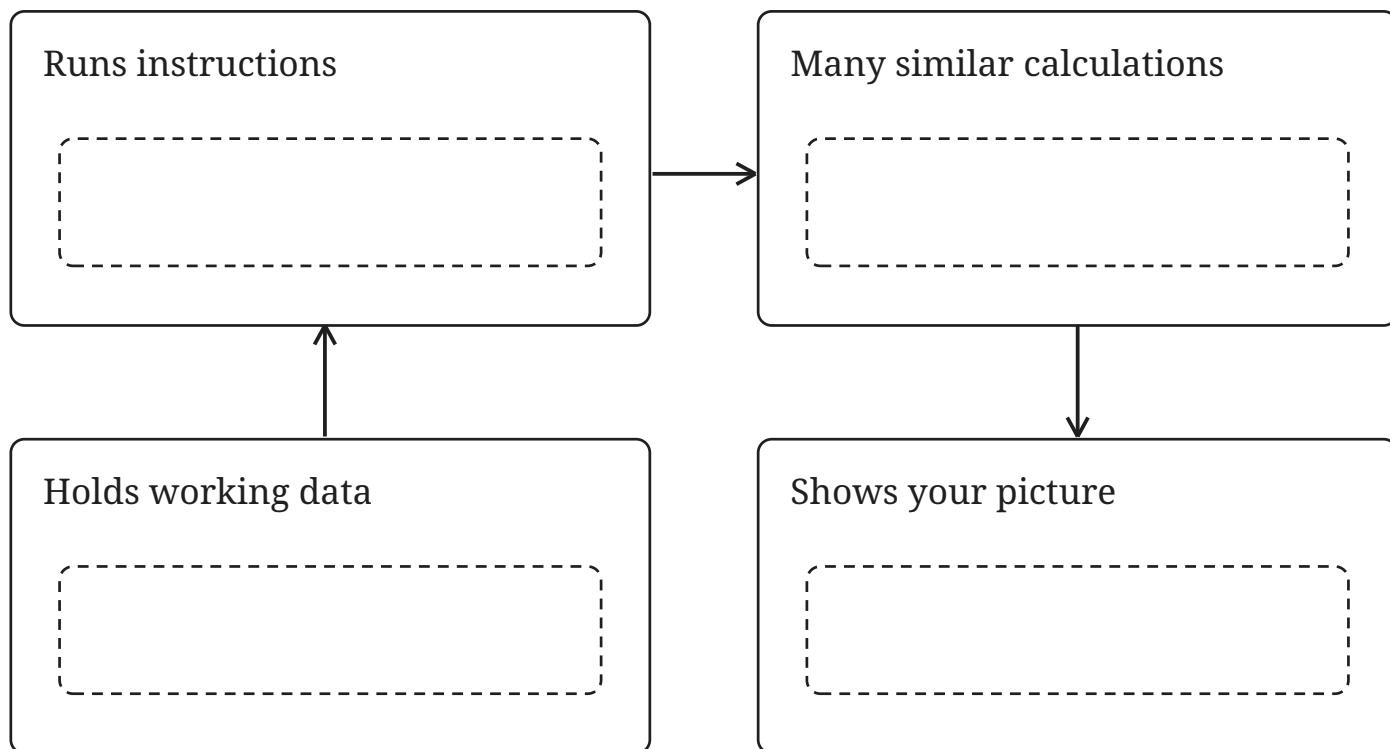
Write the addresses to repair.

Changed pixel	Row	Column
1		
2		
3		
4		

Finding a difference is useful. Explaining exactly where it is makes the repair possible.

Build a paper computer

Cut out the four crew cards. Glue each onto the matching space.



CUT CARDS

CPU

GPU

MEMORY

DISPLAY

Arrows show a simplified example. Real parts exchange data through more connections than these.

Some jobs must wait

Put these five cards in order. Write 1-5 in the small boxes.

A

Display the finished picture.

B

Read the request: draw a red square.

C

Fill in the square's pixels.

D

Choose the square's position and size.

E

Check that all the square's pixels are ready.

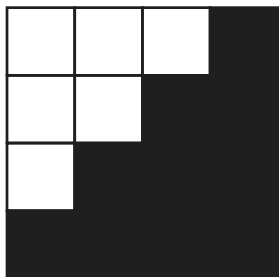
Why must checking happen before display in this job?

A dependency means one job needs the result of another. Those jobs cannot simply swap order.

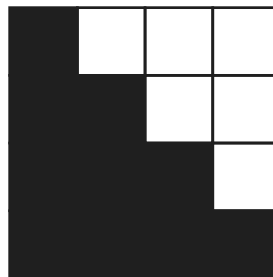
Which jobs can overlap?

The picture is split into four tiles. Each worker has its tile's instructions.

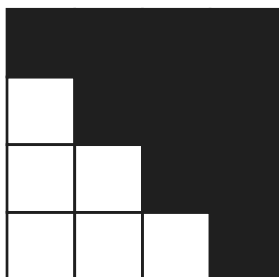
TILE A



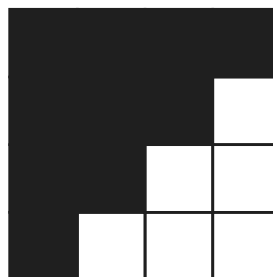
TILE B



TILE C



TILE D



Circle every pair that can work at the same time in our model.

A + B A + C C + D

Can we show the complete picture before D is ready?

These tiles are independent. Other graphics jobs can depend on earlier results.

One worker, eight jobs

Rule: one worker completes one whole tile per round. All jobs are ready.

JOB QUEUE: A B C D E F G H

Work in letter order. Write the completed tile in each round. A tile cannot be split across workers.

Round	Tile completed	Tiles completed so far
1		
2		
3		
4		
5		
6		
7		
8		

How many rounds were needed?

A round is a made-up unit for this game. It is not one second or a real GPU clock cycle.

Four workers, eight jobs

Use the same eight equal jobs. Each worker can finish one tile per round.

READY JOBS: A B C D E F G H

Round	Worker 1	Worker 2	Worker 3	Worker 4
1				
2				

Write each job exactly once. Workers can work together in the same round because these jobs are independent.

How many rounds now?

How many tiles did all four workers complete together?

We are modeling parallel work, not the exact design or speed of a particular CPU or GPU.

Compare the paper factories

All eight jobs are ready. Each equal job takes one worker one round.

Assume no waiting for data and no setup time. Fill each blank. You may draw workers or cross off job letters.

Workers	Jobs	Rounds needed
1	8	
2	8	
4	8	
8	8	

What must be true for this neat pattern to work?

This pattern is a result of our rules. Real workloads include overhead, waiting, and unequal jobs.

The lopsided queue

Workers cannot borrow jobs yet. Complete the schedule. Write - for idle.

Worker 1: A B C D E Worker 2: F
Worker 3: G Worker 4: H

Round	Worker 1	Worker 2	Worker 3	Worker 4
1				
2				
3				
4				
5				

Rounds needed:

Total idle boxes:

Each job still takes one round. Count every idle worker in every round as one idle box.

Rebalance the workload

Move jobs before work starts. Give each worker two of the eight jobs.

A B C D E F G H

WORKER 1

WORKER 2

WORKER 3

WORKER 4

Round	Worker 1	Worker 2	Worker 3	Worker 4
1				
2				

Rounds now: _____ Idle boxes now: _____

Different balanced assignments are correct. Use every job once and only once.

One instruction, many pixels

Apply the same instruction to every pixel: swap 1 and 0.

BEFORE

	1	2	3	4	5	6
1						
2						
3						
4						
5						
6						

AFTER

	1	2	3	4	5	6
1						
2						
3						
4						
5						
6						

This instruction is called an inversion in our black-and-white model: filled becomes white, and white becomes filled.

How many filled pixels are there after the swap?

Many similar operations on different data can be a good fit for parallel processing.

When instructions differ

Our four paper workers share one instruction at a time.

STAR jobs: add 1. CIRCLE jobs: subtract 1.
Round 1: only STAR jobs work. Round 2: only CIRCLE jobs work. Waiting workers write -.

Worker	1	2	3	4
Job type	STAR	CIRCLE	STAR	CIRCLE
Start number	3	7	5	9
Round 1 result				
Round 2 result				

How many waiting boxes are in the two result rows?

Challenge: if all four jobs were STAR jobs, how many shared-instruction rounds would be needed? _____

A toy illustration of shared instructions and waiting. Actual GPU execution is more complicated.

First, deliver the data

Four workers need data cards A-D. The delivery cart carries only two per round.

In this game, finish all deliveries before any calculation begins. Each worker then calculates for one round. Do not calculate during a delivery round.

A

B

C

D

Round	Cards delivered	What can the workers do?
1		Wait
2		Wait
3	None	

Delivery rounds: ____ Calculation rounds: ____

Real computers can overlap data movement and computation. This particular game deliberately does not.

Find the real hold-up

Four equal jobs need one card each. Deliver all four cards before calculating.

One worker completes one job in one round. Every factory below has enough workers to calculate all four jobs together.

Factory	Workers	Cards per round	Delivery rounds
A	4	1	
B	8	1	
C	4	2	

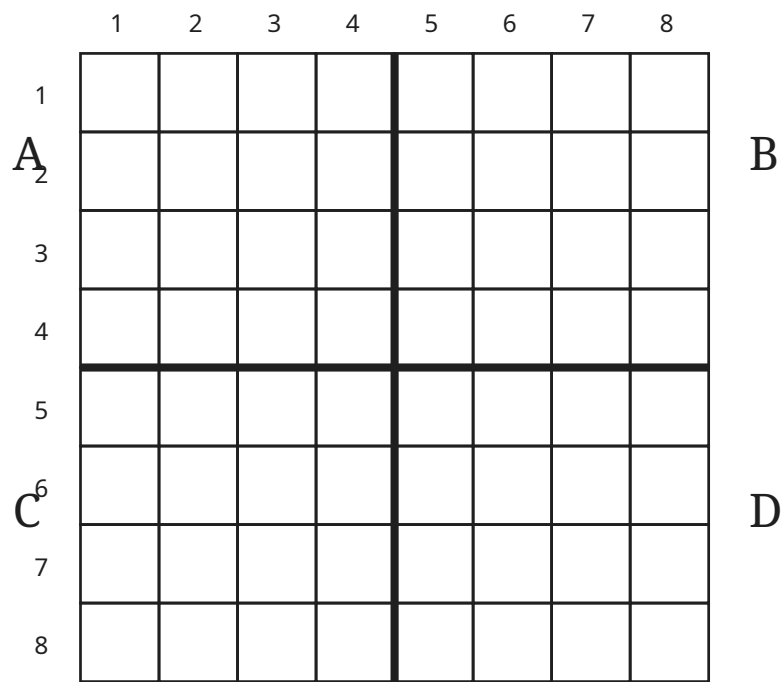
Factory	Delivery + calculation = total rounds
A	
B	
C	

Circle the fastest paper factory: A B C

More workers do not fix every delay. Our example is limited by getting the data to them.

Design a tiled scene

Create a picture with four tiles. Label them A, B, C, D in reading order.



Use black and white. Give each tile to a different imaginary worker. Agree on the tile positions before starting.

My scene is called:

How will the workers know where each tile belongs?

Extension: copy the four tiles separately. Ask a partner to assemble them using only your labels.

Debug the opening night

The screen needs tiles A, B, C, D exactly once. Find and repair the plan.

All four equal tile jobs and their data are ready. Four workers can work together. Display must wait until every tile is complete.

Faulty plan	Worker 1	Worker 2	Worker 3	Worker 4
Round 1	A	B	B	D
Round 2	DISPLAY			

Missing tile: ____ Repeated tile: ____

WRITE YOUR REPAIRED PLAN

Round	Worker 1	Worker 2	Worker 3	Worker 4
1				
2				

Tell someone why adding more workers would not repair the original instructions by itself.

You are the debugger: check the requested result, inspect the plan, change it, and check again.

Facilitator notes

Help children explain a model, then notice what the model leaves out.

Readiness

For ages 6-7, read the prompts aloud and use pointing or spoken answers. For ages 8-9, ask children to explain the scheduling rules before calculating.

Words to keep

Pixel: one picture element. Parallel: work happening at the same time. Dependency: needing an earlier result. Data: information the computer uses.

What the CPU/GPU comparison means

CPUs and GPUs both calculate, and CPUs also do parallel work. GPUs are especially suited to many similar operations. Neither is always faster at every job.

What the paper factory leaves out

Workers are not a literal diagram of cores. Jobs are artificially equal. Rounds are not seconds. Real systems have setup costs, data movement, branching, and other limits.

Support without giving the answer

Ask: What is already ready? What must wait? Was every job used once? Which rule explains your answer? For open-ended pages, value an explainable result.

Optional extension

Repeat activity 11 with seven jobs, then nine. Children should discover that some workers can be idle in the final round. The answers are two rounds and three rounds.

Print single-sided for the cut-out activities. Actual size or fit to page both work; no physical measurement is required. Cut with adult help.

Answers: activities 1-10

Use these to discuss reasoning. Original designs can have many correct answers.

- 1 INPUT-B; INSTRUCTIONS-D; PROCESSING-A; OUTPUT-C. The left-hand sequence is 1, 2, 3, 4.
- 2 A: CPU. B: GPU. C: MEMORY. D: DISPLAY. CPU and GPU both calculate.
- 3 A heart, containing 32 filled pixels. Rows: 01100110 / 11111111 / 11111111 / 01111110 / 00111100 / 00011000 / 00000000 / 00000000.
- 4 Any eight-by-eight design is valid if each of its eight code rows has exactly eight digits and matches the drawing.
- 5 The arrow points left. There are 18 filled pixels.
- 6 Changed addresses (row, column): (1,1), (2,5), (4,3), (6,6). Flip each changed pixel to restore the original.
- 7 Top left: CPU. Top right: GPU. Bottom left: MEMORY. Bottom right: DISPLAY.
- 8 B, D, C, E, A. Checking comes after filling the pixels and before showing the complete result.
- 9 All three pairs can overlap: A+B, A+C, C+D. The complete picture must wait for D as well as A, B, C.
- 10 Rounds 1-8 finish A-H respectively. The cumulative totals are 1, 2, 3, 4, 5, 6, 7, 8. Eight rounds.

Science is also checking: if a child finds an ambiguity, talk about which rule needs to be clearer.

Answers: activities 11-20

Scheduling answers assume only the rules printed on each activity.

- 11 Two rounds; eight tiles total. Example: round 1 A/B/C/D; round 2 E/F/G/H.
- 12 With 1, 2, 4, 8 workers: 8, 4, 2, 1 rounds. Jobs must be equal, independent, ready, and without setup or data delays.
- 13 Five rounds. Worker 1 does A-E; others do F/G/H in round 1 then wait. Twelve idle boxes.
- 14 Two rounds and zero idle boxes. Any assignment with two unique jobs per worker works.
- 15 16 filled pixels. Rows: 110011 / 100001 / 001100 / 001100 / 100001 / 110011.
- 16 Round 1: 4 / - / 6 / -. Round 2: - / 6 / - / 8. Four waiting boxes. All STAR jobs need one round.
- 17 Two delivery rounds, then one calculation round. Example deliveries: A+B, then C+D.
- 18 A: $4+1=5$ rounds. B: $4+1=5$. C: $2+1=3$. C finishes first under these rules.
- 19 Any design works. The four tile labels or coordinates must say where each belongs.
- 20 C is missing; B repeats. Round 1: A/B/C/D in any assignment. Round 2: display the complete picture.

SCIENCE REFERENCE

Intel, CPU vs. GPU: What's the Difference?

intel.com/content/www/us/en/products/docs/processors/cpu-vs-gpu.html

Original paper activities. Reference checked October 2026. Not affiliated with or endorsed by Intel.