

Measurement, SI Units, and Scientific Notation

Name	Block	Date
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QUESTION 1

Three lab groups measure the same track. They report 1.50m, 150cm, and 1500mm. The numbers look different even though the track is not. Explain why a shared system of units is useful in science. What information must always accompany a measured number?

QUESTION 2

Give the SI unit symbol for each measured quantity.

- a)** length
- b)** mass
- c)** time
- d)** temperature
- e)** electric current

a) m | **b)** kg | **c)** s | **d)** K | **e)** A

QUESTION 3

A lab track is 1.50m long. A cart is 6.40cm wide and carries a 0.850mm photogate flag. Express every length in metres.

- a)** track length
- b)** cart width
- c)** flag thickness

a) 1.50m | **b)** 0.0640m | **c)** 0.000850m

QUESTION 4

A runner completes 5.00km in 24.0min. Determine the average speed in metres per second.

3.47m/s

QUESTION 5

A student reports a cart's speed as "3.5" and says the calculation is finished. Explain why the number alone does not describe a physical measurement. Give two different quantities that could both have the numerical value 3.5.

QUESTION 6

A radio wavelength is written as 0.000000650m. A different source writes it as $6.50 \times 10^{-7}\text{m}$. Explain why the second form may be easier to read, compare, and use without claiming that the first value is wrong.

QUESTION 7

Write each measurement in scientific notation.

- a)** 0.0000420s
- b)** 125000Hz
- c)** 384400000m

a) $4.20 \times 10^{-5}\text{s}$ | **b)** $1.25 \times 10^5\text{Hz}$ | **c)** $3.844 \times 10^8\text{m}$

QUESTION 8

A dust particle has a mass of $4.0 \times 10^{-9} \text{ kg}$. Determine the mass of 5.0×10^6 identical particles.

$2.0 \times 10^{-2} \text{ kg}$

QUESTION 9

Caleb converts 72.0km/h to metres per second by multiplying by 1000 and then multiplying by 3600.

- a)** Calculate the value produced by Caleb's method.
- b)** Explain the error in his treatment of hours.
- c)** Calculate the correct speed in metres per second.

a) $2.592 \times 10^8 \text{ m/s}$ | **b)** divide by 3600 when converting hours to seconds | **c)** 20.0m/s

QUESTION 10

A radio signal travels at $3.00 \times 10^8 \text{ m/s}$ for 2.50ms. Determine the distance travelled in kilometres.

750km

QUESTION 11

Aluminium has a density of 2.70g/cm^3 . Express this density in kilograms per cubic metre.

2700kg/m^3

QUESTION 12

A cell is $2.4 \times 10^{-6} \text{ m}$ wide and a virus is $8.0 \times 10^{-9} \text{ m}$ wide. Determine how many times wider the cell is than the virus.

300 times

Significant Figures and Measurement Uncertainty

Name

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QUESTION 1

Two rulers are used to measure the same object. One has marks every centimetre. The other has marks every millimetre. Both students enter the measurement into a calculator that displays eight decimal places. Should both final reports contain eight decimal places? Explain what actually limits the precision of a measured result.

QUESTION 2

State the number of significant figures in each measurement.

- a)** 0.00450m
- b)** 12.030s
- c)** 8000g
- d)** 8.000×10^3 g

a) 3 | **b)** 5 | **c)** 1 | **d)** 4

QUESTION 3

A measured length is calculated using $(12.4\text{cm} + 3.15\text{cm}) \div 2.0$.

- a)** Evaluate the numerator using the addition rule.
- b)** Report the final result using the multiplication and division rule.

a) 15.6cm | **b)** 7.8cm

QUESTION 4

A sample has a mass of $(18.2\text{g} - 2.35\text{g})$ and a volume of 4.0cm^3 . Determine its density with proper precision.

4.0g/cm^3

QUESTION 5

Two students calculate 6.2×3.14 . One reports 19.468 and the other reports 19. Which report has the proper precision? Justify the choice.

QUESTION 6



The thermometer has divisions every 0.1°C.

- a) Record the best reading, including one estimated digit.
- b) Use half the smallest division as the uncertainty.
- c) Report the measurement as value $\pm$ uncertainty.

a) 20.73°C | b) 0.05°C | c) 20.73 $\pm$ 0.05°C

QUESTION 7

Five trials give 1.82s, 1.76s, 1.79s, 1.85s, and 1.78s. Report the result as the mean $\pm$ half the range, rounding the uncertainty to one significant figure.

1.80 $\pm$ 0.05s

QUESTION 8

Two groups measure the same speed. Group A reports $3.42 \pm 0.08 \text{ m/s}$ and Group B reports $3.57 \pm 0.06 \text{ m/s}$.

- a)** State Group A's interval.
- b)** State Group B's interval.
- c)** Do the intervals overlap?

a) 3.34-3.50m/s | **b)** 3.51-3.63m/s | **c)** no

QUESTION 9

A student says, "A measurement with a small uncertainty must be close to the accepted value."
Explain why precision and accuracy are different. Describe a set of measurements that is precise but inaccurate.

Scalars and Vectors

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QUESTION 1

Two hikers each report that they travelled 5.0km from the same starting point. They did not finish at the same place. What information is missing from the statement “5.0km”? Explain why some physical descriptions need more than a size and unit.

QUESTION 2

Classify each quantity as a scalar or a vector.

- a)** the temperature of a classroom
- b)** the velocity of a baseball
- c)** the length of a soccer field
- d)** the displacement of a runner
- e)** the mass of a textbook

a) scalar | **b)** vector | **c)** scalar | **d)** vector | **e)** scalar

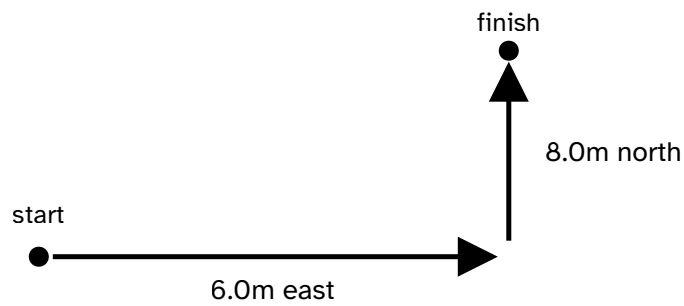
QUESTION 3

A person walks 1.0m east, 3.0m west, then 12m east.

- a)** Determine the distance travelled.
- b)** Determine the displacement.

a) 16m | **b)** 10m east

QUESTION 4



Determine the hamster's displacement from the route shown, including magnitude and direction.

10m, 53° N of E

QUESTION 5

Jane drives 100km west, 50km south, then 100km north.

- a) Draw her path.
- b) Determine the distance travelled.
- c) Determine her displacement.

b) 250km | c) 112km, 27° N of W

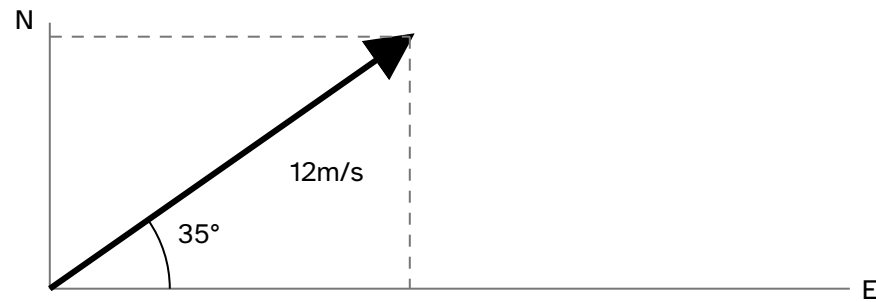
QUESTION 6

Daniel runs three complete laps of a 400m circular track.

- a)** Determine the distance travelled.
- b)** Determine the displacement.
- c)** A classmate says that zero displacement means Daniel did not move. What does zero displacement actually tell us? What does it not tell us?

a) 1200m | **b)** 0m

QUESTION 7



The velocity vector shown has a magnitude of 12m/s .

- a) Determine its east component.
- b) Determine its north component.

a) 9.8m/s east | b) 6.9m/s north

QUESTION 8

Your younger sibling asks why “5m/s” and “5m/s east” do not mean the same thing. Explain the difference without using the words scalar or vector until the end of your explanation.

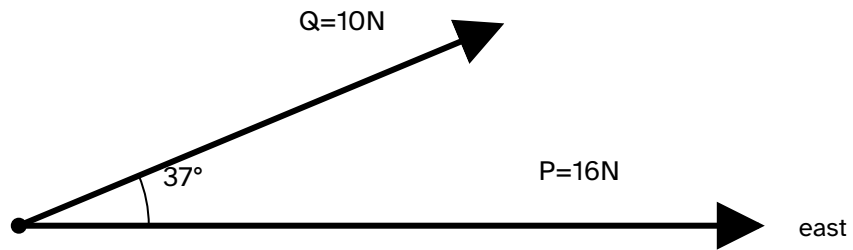
QUESTION 9



A boat points straight north through the water at 3.0m/s while the river flows east at 1.2m/s . Determine the boat's velocity relative to the ground, including magnitude and direction.

3.2m/s , 22° E of N

QUESTION 10



Vector P is 16N east. Vector Q is 10N at 37° north of east. Determine $P - Q$, expressed as magnitude and direction.

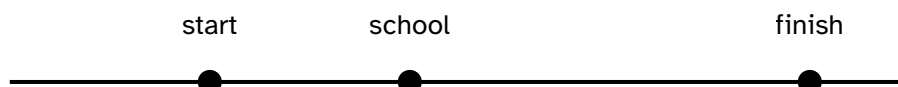
10N, 37° S of E

Uniform Motion

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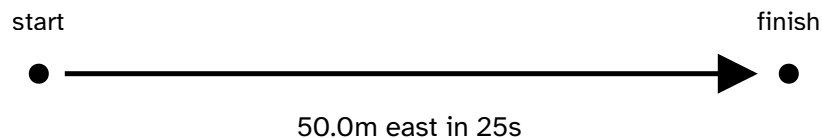
QUESTION 1

A cyclist begins 200m west of the school and reaches a point 400m east of the school 5.0 minutes later. We do not know what happened during the trip. The cyclist might have sped up, slowed down, or stopped. What we do know is where the cyclist started, where the cyclist ended, and how long the trip took.

- a)** Determine the cyclist's average velocity.
- b)** What does this answer tell us about the trip?
- c)** What does it not tell us?

a) 2.0m/s east

QUESTION 2



Miranda says, "I walked 50.0m in 25s." Her friend immediately says her average velocity was 2.0m/s. Miranda disagrees. She says there is not enough information yet.

- a) Who do you agree with? Explain.
- b) What information is missing?
- c) Miranda then says she walked east. Determine her average velocity.

b) direction | c) 2.0m/s east

QUESTION 3

A store is 3.0km from Jordan's house. Jordan walks to the store and returns home in 2.0h. His average velocity for the entire trip is zero, but he clearly did not stand still.

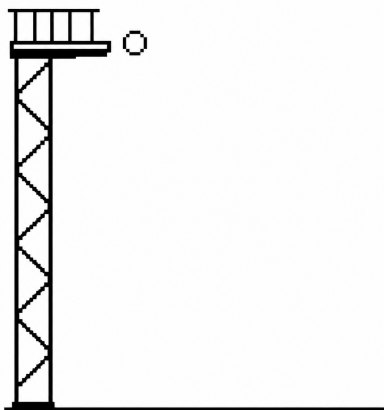
- a)** Explain how his average velocity can be zero.
- b)** Determine his average speed.

b) 3.0km/h

QUESTION 4

Nadia and Mateo leave the school together and reach the same bus stop at the same time. Nadia walks steadily. Mateo runs, stops to tie a shoe, and then walks slowly. Somehow, their average velocities are equal. How can that be? What does the shared average tell us? What does it completely miss?

QUESTION 5



A ball is dropped from rest 10m above the ground and reaches the ground 1.43s later. Someone asks, “What was its speed?” Amy replies, “Which speed? It was speeding up the whole way.” She says we cannot give one speed for the entire fall, but we can calculate an average velocity because we know the displacement and the total time.

- a) Explain what Amy means by average velocity.
- b) Determine the ball’s average velocity. Up is positive.

b) -7.0m/s

QUESTION 6

Alice and Bob leave the same location together. Alice walks right at 1.5m/s while Bob walks left at 1.2m/s. Determine how far apart they are after 44s.

119m

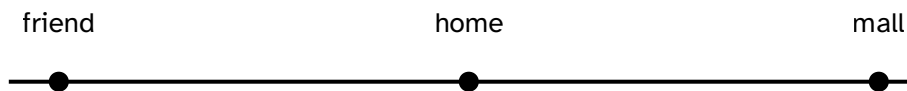
QUESTION 7

A car travels 250km at 75km/h, stops for 1.0h, then travels another 150km at 90km/h. Do not forget the stop. The car is not moving, but the trip clock is still running.

- a)** Determine the total distance.
- b)** Determine the total trip time.
- c)** Determine the average speed.

a) 400km | **b)** 6.0h | **c)** 66.7km/h

QUESTION 8



The mall is 3.0km east of Daniel's home and his friend's house is 2.5km west of home. Daniel reaches the mall in 0.50h, stays for 1.0h, then reaches his friend's house 2.0h later. Determine his average speed and average velocity for the complete trip.

2.43km/h, 0.71km/h west

QUESTION 9



A maintenance cart travels 180m east at 4.0m/s, waits for 30s, then travels 60m west at 2.0m/s. Determine its average speed and average velocity from departure until the end of the trip.

2.29m/s, 1.14m/s east

Constant Acceleration

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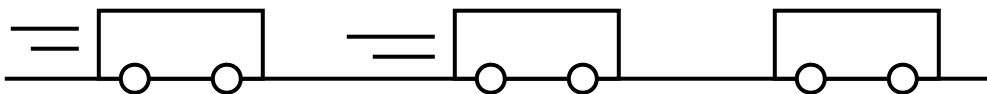
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QUESTION 1

Car A gains 12m/s of velocity in 3.0s. Car B gains the same 12m/s in 6.0s. There is clearly something different about how their motion changes. What is different? Which car changes velocity faster? What do we call the rate at which velocity changes?

Car A changes velocity faster; the rate of change of velocity is acceleration: 4.0m/s^2 for A and 2.0m/s^2 for B

QUESTION 2



A car moving right at 13m/s comes to rest in 8.0s. Right is positive.

- a) List the known quantities.
- b) Predict the sign of the acceleration.
- c) Determine the acceleration.

a) $v_i = 13\text{m/s}$ right, $v_f = 0\text{m/s}$, $t = 8.0\text{s}$ | b) negative | c) -1.63m/s^2

QUESTION 3

A car accelerates from 10m/s to 30m/s while travelling 500m, then brakes at -3.2m/s^2 until it stops.

- a)** Determine its acceleration during the first stage.
- b)** Determine how long the braking stage lasts.

a) 0.80m/s^2 | **b)** 9.4s

QUESTION 4

A cart moving right at 6.0m/s accelerates at 2.0m/s^2 over 80m . Determine its final velocity.

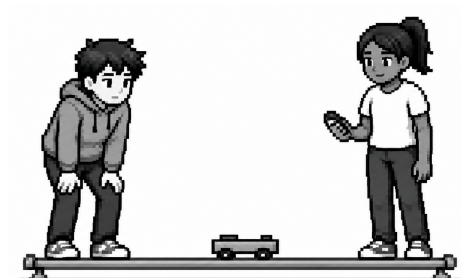
18.9m/s right

QUESTION 5

A driver moving right at 24m/s stops uniformly in 6.0s. Determine the acceleration.

-4.0m/s²

QUESTION 6



A student says, “Negative acceleration means an object is slowing down.” Explain why this idea seems reasonable, then give one example in which negative acceleration makes an object speed up.

negative acceleration means acceleration points in the negative direction; an object moving in the negative direction speeds up when its acceleration is also negative

QUESTION 7

A car starts from rest, accelerates right at 3.0m/s^2 for 5.0s , then continues at constant velocity for 8.0s . Determine its total displacement.

158m right

QUESTION 8

A car accelerates uniformly from rest to 20m/s in 4.0s, then travels at 20m/s for 6.0s. A student claims the average velocity for the entire trip is 10m/s because that is the average of 0m/s and 20m/s.

- a)** Explain why the method does not apply to the whole trip.
- b)** Determine the correct average velocity.

a) the two stages require time-weighted displacement | **b)** 16m/s

Free Fall and Vertical Motion

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QUESTION 1

Consider a ball thrown straight upward. Bob claims that at the highest point, both its velocity and acceleration are zero. Which part of Bob's claim is true? Which part is false? If both quantities were zero, what would happen to the ball?

the velocity is zero for an instant, but acceleration remains 9.8m/s^2 downward; if both stayed zero, the ball would remain at rest at the top

QUESTION 2

Up is positive. Ignore air resistance. The ball's acceleration stays at -9.8m/s^2 throughout the flight, but its velocity does not.

- a)** While the ball is moving upward, state the sign of its velocity and whether its speed is increasing or decreasing.
- b)** At the highest point, state its velocity and acceleration.
- c)** While the ball is moving downward, state the sign of its velocity and whether its speed is increasing or decreasing.

a) positive; speed decreasing | **b)** 0m/s ; acceleration remains -9.8m/s^2 | **c)** negative; speed increasing

QUESTION 3

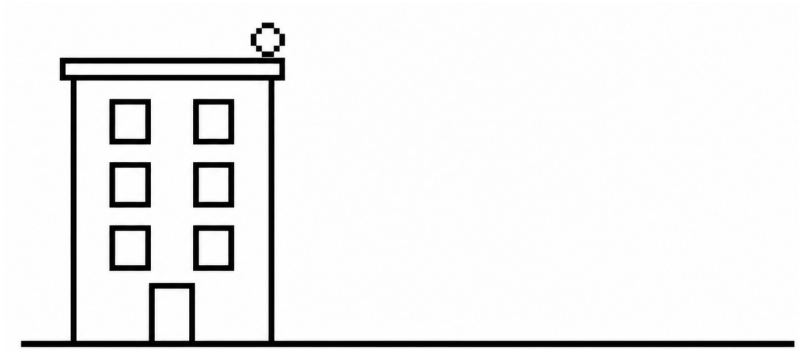


A student throws a ball upward from the ground at 12m/s .

- a)** Determine the maximum height.
- b)** Determine the total time before it returns to the ground.

a) 7.35m | **b)** 2.45s

QUESTION 4



A ball is thrown upward at 8.0m/s from a roof 12m above the ground.

- a)** Determine its velocity immediately before impact.
- b)** Determine the time required to reach the ground.

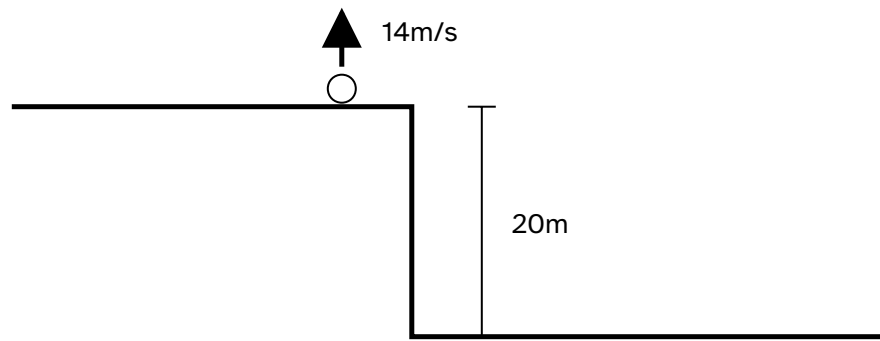
a) -17.3m/s | **b)** 2.58s

QUESTION 5

A ball is thrown downward at 4.0m/s from a point 15m above the ground. Determine its impact velocity and then its time to reach the ground.

-17.6m/s, 1.39s

QUESTION 6



A ball is thrown upward at 14m/s from a point 20m above the ground.

- a)** Determine its maximum height above the ground.
- b)** Determine its velocity immediately before impact.

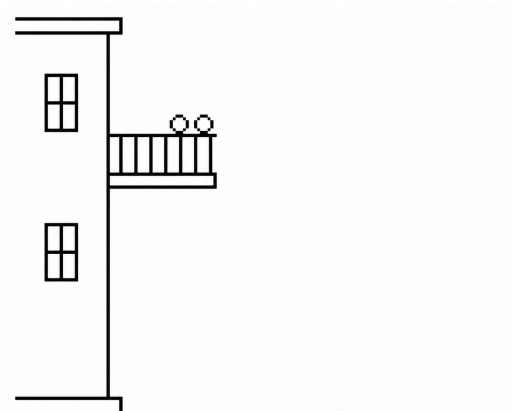
a) 30m | **b)** -24.2m/s

Horizontally Launched Projectiles

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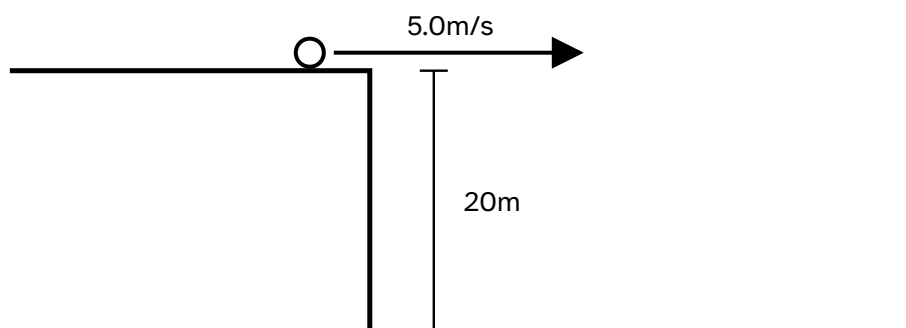
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QUESTION 1

Two balls leave the same balcony at the same instant. Ball A is dropped. Ball B is launched horizontally. Their vertical motion begins in exactly the same way, but Ball B is also moving sideways. Which one lands first? Many students say Ball B must stay in the air longer because it has farther to travel. Do you agree? Explain.

they land at the same time because their vertical initial velocities, vertical accelerations, and vertical displacements are the same

QUESTION 2



A ball is launched horizontally from the cliff shown. Up and right are positive.

- a)** List the known quantities. Organize them so it is clear which describe horizontal motion and which describe vertical motion.
- b)** Determine the flight time.
- c)** Determine the range.

a) horizontal: $v_i = 5.0\text{m/s}$ right, $a = 0$; vertical: $v_i = 0\text{m/s}$, $a = -9.8\text{m/s}^2$, $d = -20\text{m}$ | **b)** 2.02s | **c)** 10.1m

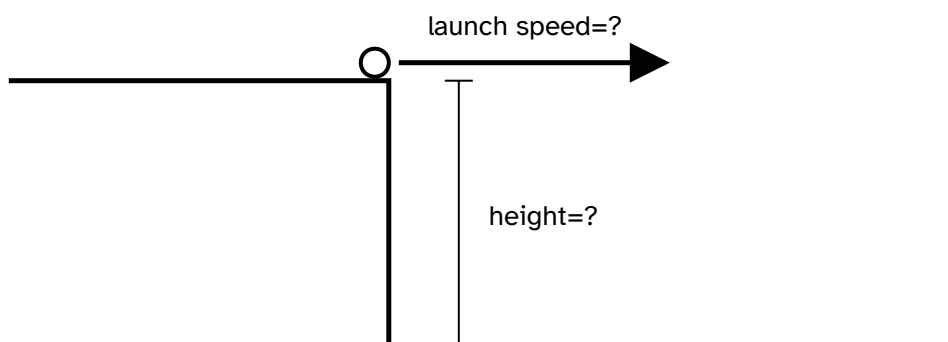
QUESTION 3

A ball is launched horizontally at 3.0m/s from a point 12m above the ground.

- a)** Determine its range.
- b)** Determine its impact velocity, including direction.

a) 4.69m | **b)** 15.6m/s, 79° below

QUESTION 4

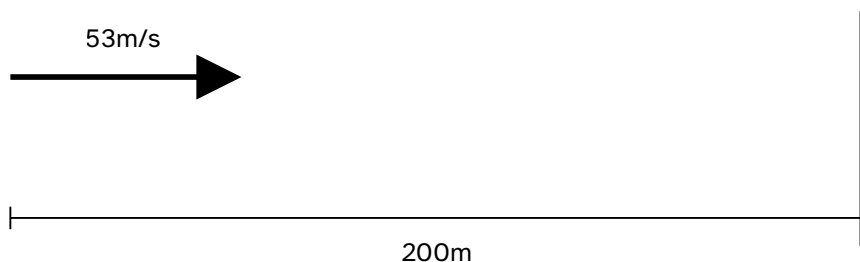


A ball is launched horizontally from a cliff. It reaches the ground after 7.0s and lands 30m from the base. This time, work backward from the landing.

- a) Determine the cliff height.
- b) Determine the launch velocity.

a) 240m | b) 4.29m/s

QUESTION 5

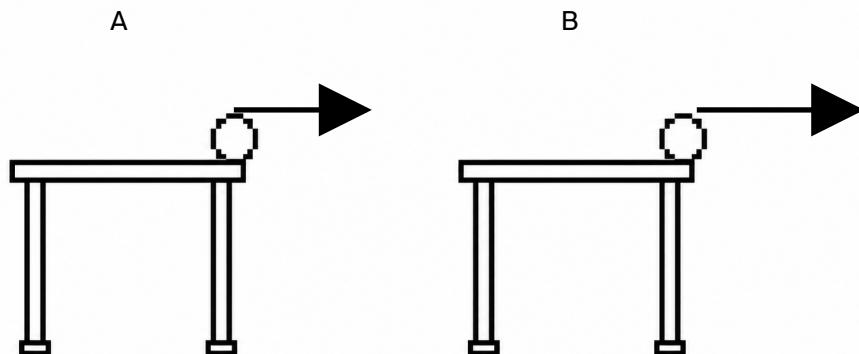


An arrow is fired horizontally at 53m/s from 1.5m above the ground toward a wall 200m away.

- Ignoring the ground, determine the time to the wall and the implied vertical drop.
- Explain what the result reveals about whether the arrow can reach the wall.
- Calculate the horizontal distance travelled before the arrow reaches the ground.

a) 3.77s and 69.8m | **b)** it hits the ground before reaching the wall | **c)** 29.3m

QUESTION 6

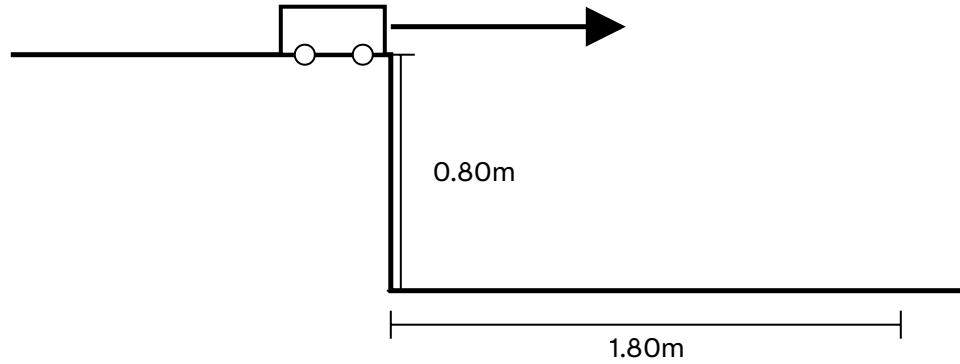


Two balls roll from the same table at the same instant. Ball A leaves at 2.0m/s and Ball B leaves at 5.0m/s .

- a) Without calculating, compare their flight times and explain your reasoning.
- b) Which lands farther from the table?
- c) Which has the greater impact speed?

a) equal | b) ball B | c) ball B

QUESTION 7



A toy car must land 1.80m from the edge of a 0.80m-high table. Determine the required horizontal velocity.

4.45m/s

Angled Projectiles

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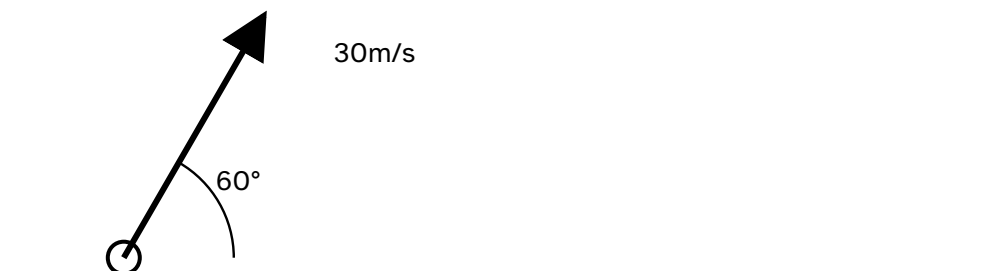
Date _____

QUESTION 1

Jun kicks a soccer ball with a launch speed of 20m/s . His friend says, “Then its initial horizontal velocity is 20m/s and its initial vertical velocity is also 20m/s .” Is his friend correct? Explain why or why not. What additional information is needed before the horizontal and vertical components can be determined?

no; the launch angle is needed

QUESTION 2



A soccer ball is launched from level ground as shown.

- a)** Determine the initial horizontal component.
- b)** Determine the initial vertical component.
- c)** Determine the total flight time.
- d)** Determine the range.
- e)** Determine the maximum height.
- f)** Determine the velocity after 1.0s.

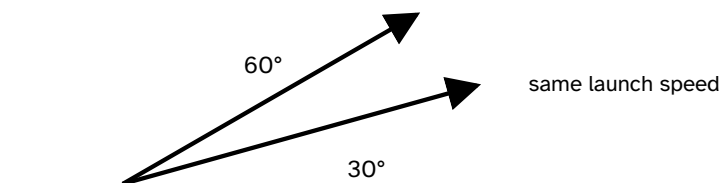
a) 15.0m/s | **b)** 26.0m/s | **c)** 5.30s | **d)** 79.5m | **e)** 34.4m | **f)** 22.1m/s, 47° above

QUESTION 3

A driving range has a safety net 350m from the tee. A golf ball is struck from level ground at 70m/s and 25° above the horizontal. Ignore air resistance. Determine the ball's range. Will it reach the net before landing?

383m; yes

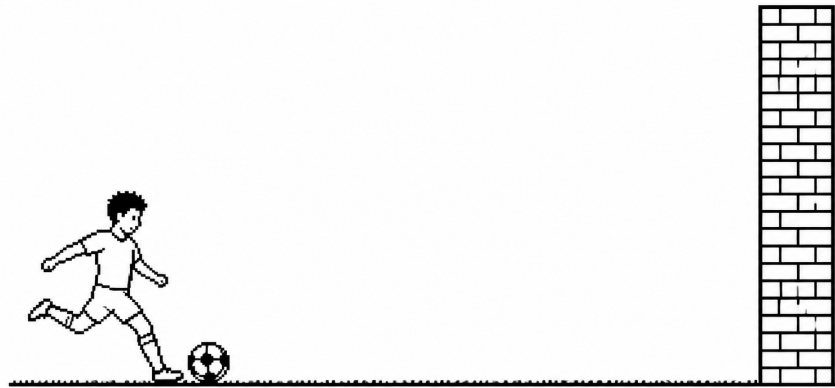
QUESTION 4



Two balls are launched from level ground with the same speed, one at 30° and the other at 60° . Predict and compare their flight times, maximum heights, and ranges. Explain why equal ranges do not mean identical motion.

60° : longer time and greater height; equal range

QUESTION 5



A soccer ball is kicked from level ground at 12m/s and 33° above the horizontal toward a wall 5.0m away. Determine the height at which it reaches the wall.

2.04m

QUESTION 6

Mateo resolves a 20m/s launch at 30° above horizontal.

He writes:

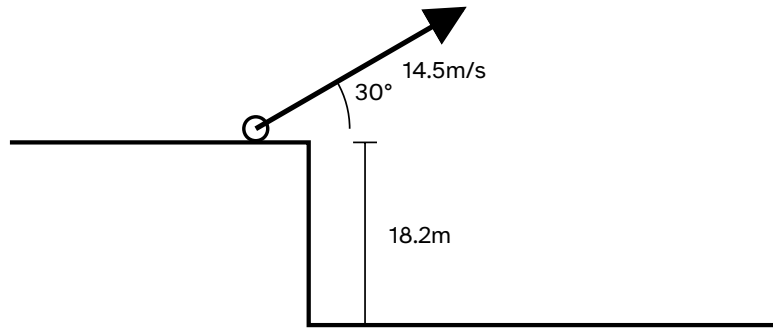
$$v_{ix} = 20 \sin 30^\circ = 10 \text{ m/s}$$

$$v_{iy} = 20 \cos 30^\circ = 17.3 \text{ m/s}$$

Something is wrong. What is Mateo's mistake? How do you know?

sine and cosine were switched; $v_{ix} = 17.3 \text{ m/s}$ right and $v_{iy} = 10 \text{ m/s}$ up

QUESTION 7



A ball is launched from the cliff shown. Determine its impact velocity, including direction.

23.8m/s, 58° below the horizontal

QUESTION 8



A basketball is released 2.0m above the floor at 10m/s and 80° above the horizontal. The net is 4.0m high.

- a) Determine the two possible vertical velocities when the ball is level with the net.
- b) Explain why the calculation produces two answers.
- c) Draw the path and mark where each velocity occurs.

a) $\pm 7.60\text{m/s}$ | b) the ball crosses 4.0m upward and downward

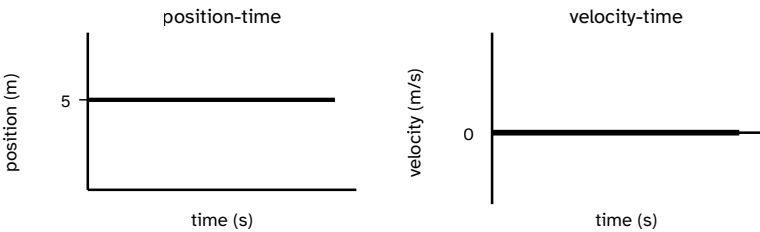
Position-Time and Velocity-Time Graphs

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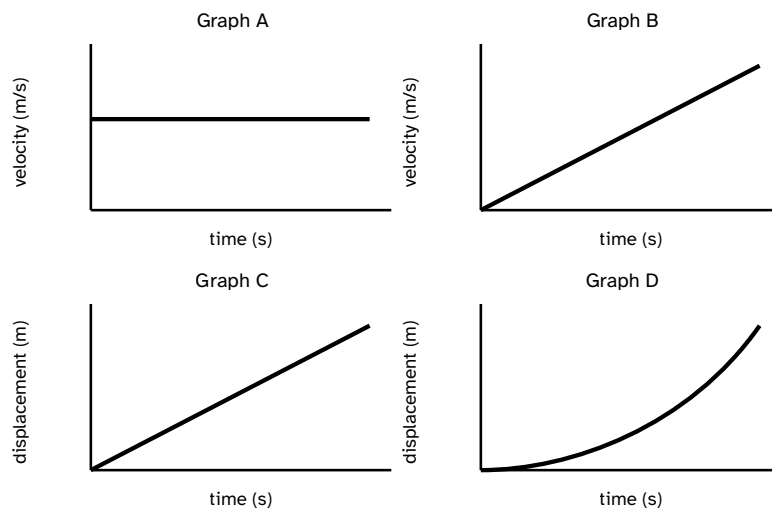
QUESTION 1



A person stands still 5m east of a marker for 10s. Do these graphs make sense? Do not decide from their shapes. Read the axes. What does each graph say, and why do both agree with someone standing still?

Do not proceed until this question makes 100% sense to you.

QUESTION 2



Graphs A and B show two cars moving right. Graphs C and D show the same two trips.

DO NOT MATCH THE SHAPES. DO NOT MEMORIZE THE SHAPES. READ THE GRAPH.

- a)** Describe in plain English how the car in Graph A is moving.
- b)** Describe in plain English how the car in Graph B is moving.
- c)** Match Graphs C and D to Graphs A and B.
- d)** The slope of a displacement-time graph is velocity. Explain how the slopes support your matches.

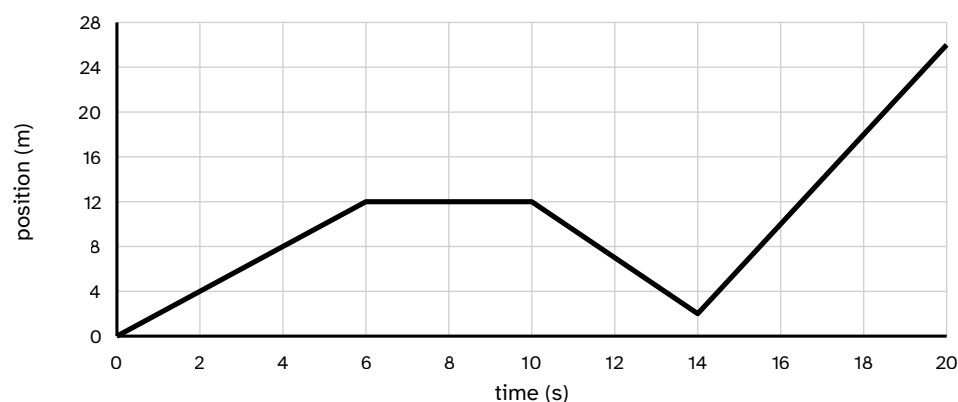
a) moving right at constant velocity | **b)** speeding up to the right | **c)** A matches C; B matches D

QUESTION 3

Use right as positive for the cars and up as positive for the ball.

- a)** A car moves right at constant velocity. Draw both a position versus time graph and a velocity versus time graph.
- b)** A ball is released from rest and falls. Draw both a position versus time graph and a velocity versus time graph.
- c)** A car moves left at constant velocity. Draw both a position versus time graph and a velocity versus time graph.

QUESTION 4

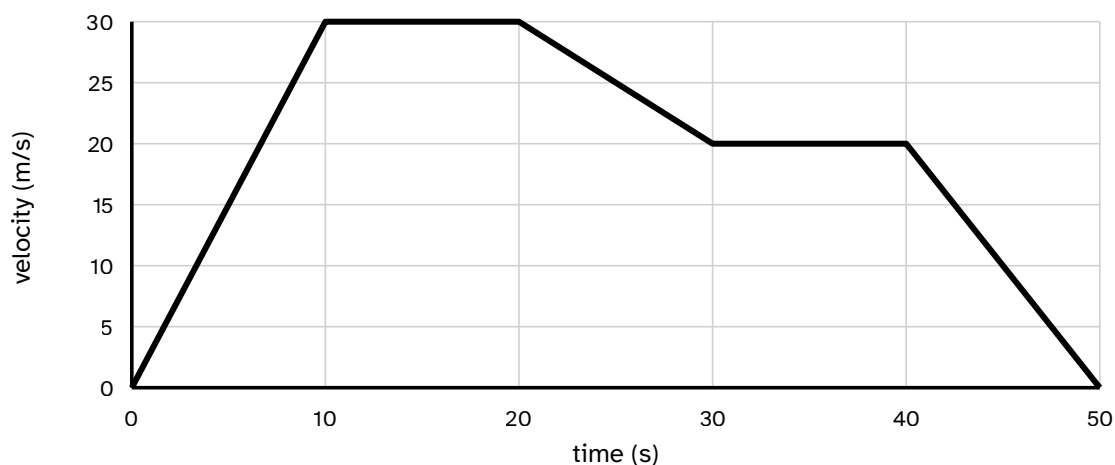


Read the position-time graph from left to right. Before calculating, describe what the object is doing during each section. Then answer the questions.

- a) When is the object moving fastest?
- b) When is it moving right?
- c) When is it moving left?
- d) When is it stopped?
- e) Determine the total distance.
- f) Determine the average velocity.

a) 14s-20s | b) 0s-6s, 14s-20s | c) 10s-14s | d) 6s-10s | e) 46m | f) 1.3m/s

QUESTION 5



Use the velocity-time graph.

- a) State the greatest velocity.
- b) When does it occur?
- c) State the least velocity.
- d) When does it occur?
- e) When is the object moving right?
- f) When is it moving left?
- g) When is it speeding up?
- h) When is it slowing down?
- i) When is the acceleration zero?
- j) Determine the displacement.

a) 30m/s | b) 10s-20s | c) 0m/s | d) 0s and 50s | e) 0s-50s | f) never | g) 0s-10s | h) 20s-30s, 40s-50s | i) 10s-20s, 30s-40s | j) 1000m

QUESTION 6

A cyclist starts 20m east of a marker, rides left at 4.0m/s for 5.0s, waits for 3.0s, then rides right at 2.0m/s for 8.0s. Draw a position-time graph and a velocity-time graph for the complete motion.

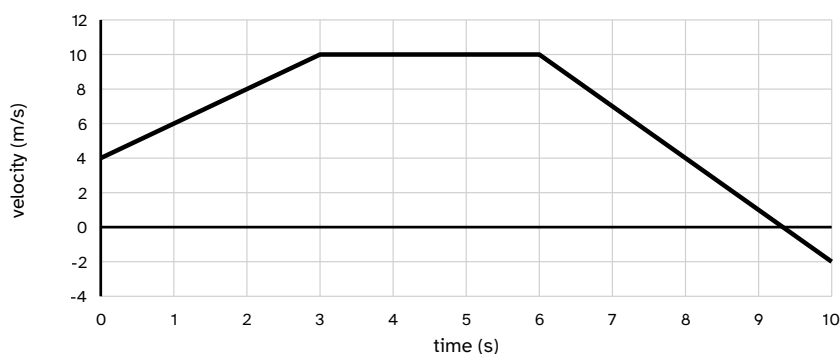
Acceleration and Motion Graphs

Name	Block	Date
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QUESTION 1

You already know how to read a velocity-time graph: the vertical axis gives velocity and the horizontal axis gives time. Now compare two moments. How much did the velocity change? How much time passed? What does one change divided by the other tell you? Explain why this is acceleration, and why it is also the slope of the graph.

QUESTION 2

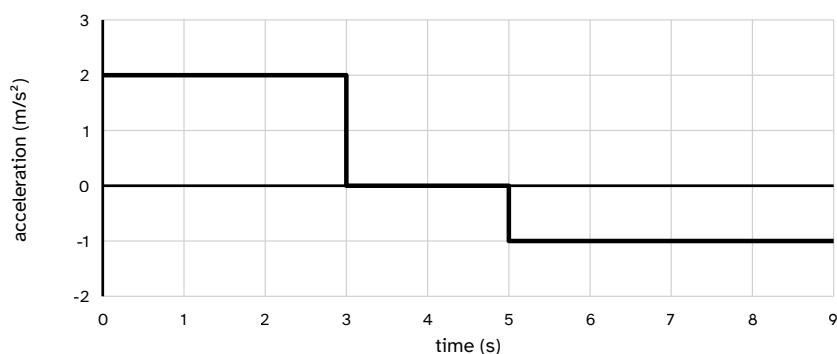


The velocity-time graph shows one object moving along a straight line. Read the graph before calculating.

- Describe the motion from 0s to 3s, from 3s to 6s, and from 6s to 10s in plain English.
- Determine the acceleration from 0s to 3s.
- Determine the acceleration from 3s to 6s.
- Determine the acceleration from 6s to 10s.
- Determine when the object reverses direction.
- Draw the corresponding acceleration-time graph.

a) speeds up right; constant right; slows, reverses, then speeds up left | **b)** 2.0m/s^2 | **c)** 0m/s^2 | **d)** -3.0m/s^2 | **e)** 9.33s

QUESTION 3

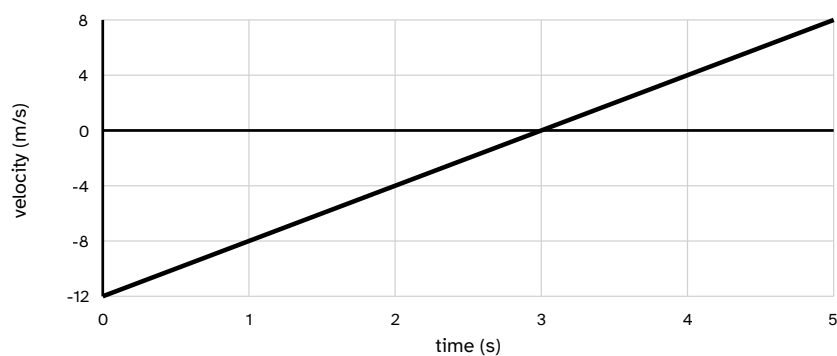


The acceleration-time graph describes an object with an initial velocity of -2.0 m/s .

- a)** Before calculating, explain what happens to the velocity during each section of the graph.
- b)** Determine the velocity at 3s.
- c)** Determine the velocity at 5s.
- d)** Determine the velocity at 9s.
- e)** Draw the velocity-time graph.
- f)** Sketch the shape of the position-time graph.

a) velocity increases; stays constant; then decreases | **b)** 4.0 m/s | **c)** 4.0 m/s | **d)** 0 m/s

QUESTION 4



The velocity-time graph shows a car moving along a straight road.

- a)** Describe the car's motion in plain English.
- b)** Determine the car's acceleration.
- c)** When does the car change direction?

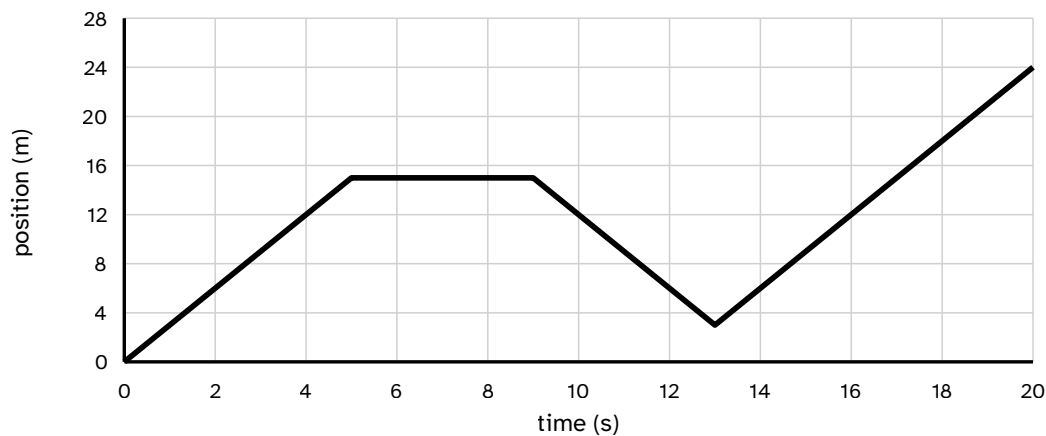
a) starts moving left, slows to rest, then moves right and speeds up | **b)** 4.0 m/s^2 right | **c)** 3.0s

Kinematics Review and Mixed Representations

Name _____

Block _____

Date _____

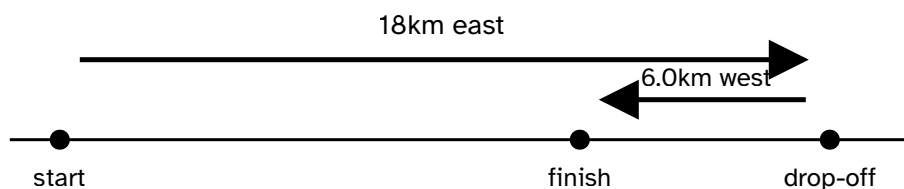
QUESTION 1

A cart moves according to the position-time graph.

- a)** Read from left to right and tell the complete story of the cart's motion in plain English.
- b)** Determine the velocity from 0s to 5s.
- c)** Determine the velocity from 5s to 9s.
- d)** Determine the velocity from 9s to 13s.
- e)** Determine the velocity from 13s to 20s.
- f)** Determine the total distance.

b) 3.0m/s | **c)** 0m/s | **d)** -3.0m/s | **e)** 3.0m/s | **f)** 48m

QUESTION 2



A delivery van travels 18km east in 0.30h, waits for 0.20h, then travels 6.0km west in 0.10h.

- Determine its average speed.
- Determine its average velocity.
- The van does not move while it waits. Why does the waiting time still affect both averages?

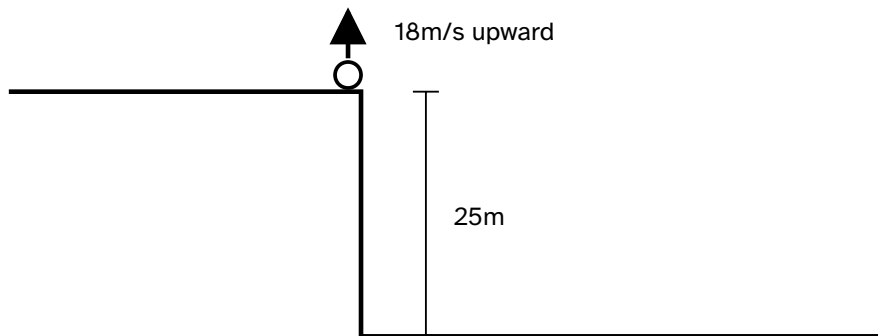
a) 40km/h | **b)** 20km/h east | **c)** the waiting time increases the total time without adding distance or displacement

QUESTION 3

A cyclist moving right at 5.0m/s accelerates uniformly over 52m and reaches 21m/s. Determine the acceleration and travel time.

4.0m/s², 4.0s

QUESTION 4

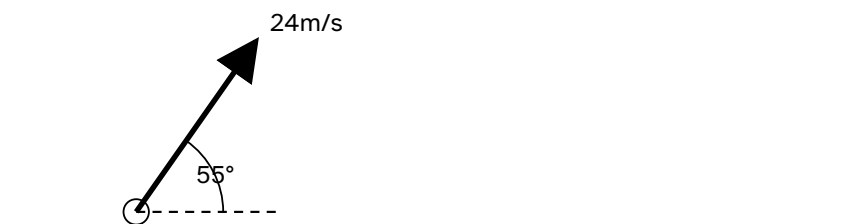


A ball is thrown upward at 18m/s from a roof 25m above the ground.

- a)** Determine its maximum height above the ground.
- b)** Determine its impact velocity.
- c)** At the highest point, what are the ball's velocity and acceleration? Explain why they are not both zero.

a) 41.5m | **b)** 28.5m/s down | **c)** velocity is zero; acceleration is 9.8m/s^2 down

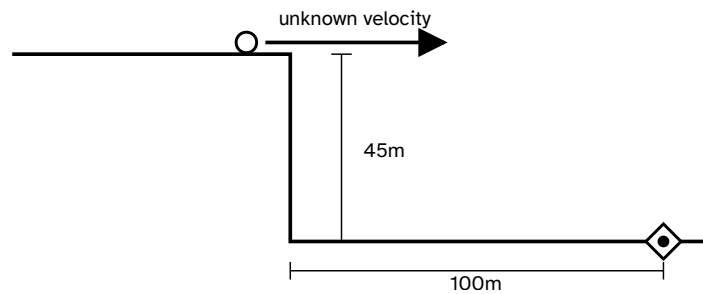
QUESTION 5



A ball is launched from level ground at 24m/s and 55° above the horizontal. At its highest point, a student says, “The ball stops for an instant, so its velocity is zero.” Is the student correct? Explain what is happening to the ball's velocity and acceleration at that instant, then determine its velocity.

no; 13.8m/s right; acceleration is 9.8m/s^2 down

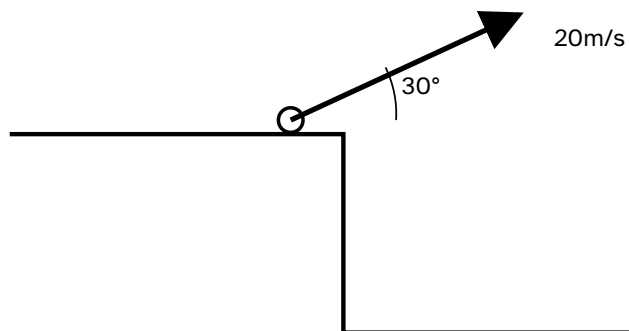
QUESTION 6



A ball is fired horizontally from a 45m cliff toward a target 100m from the base. What horizontal launch velocity will make the ball hit the target?

33.0m/s

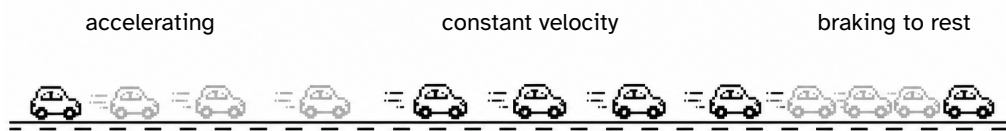
QUESTION 7



A ball is launched from the edge of a cliff at 20m/s and 30° above the horizontal. It reaches the ground 3.70s later. Determine the horizontal distance travelled and its impact velocity.

64.1m; 31.5m/s at 57° below horizontal

QUESTION 8



A car starts from rest, accelerates right at 2.5m/s^2 for 8.0s , travels at constant velocity for 12s , then brakes uniformly to rest in 5.0s .

- a)** Draw a velocity-time graph for the complete trip.
- b)** Determine the total displacement.
- c)** Determine the average velocity.
- d)** During which stage does the car travel the greatest distance? Check your prediction with the values from your solution.

b) 370m | **c)** 14.8m/s right | **d)** the constant-velocity stage

QUESTION 9

Two cars pass the same point moving right at the same speed. One is accelerating and the other is not. What observation would let you tell the difference? Describe how their motion would begin to differ after that instant.

Introduction to Force

Name	Block	Date
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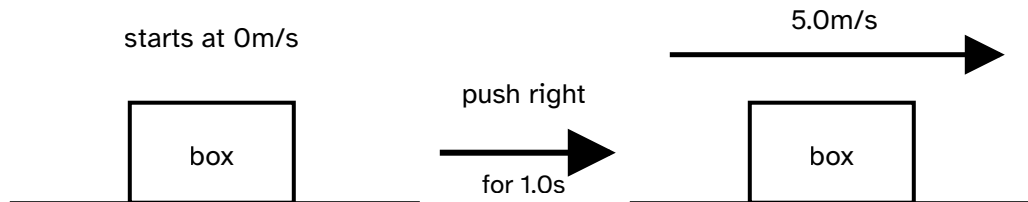
QUESTION 1

Imagine the word *force* does not exist yet. People can push a cart, pull a door, kick a ball, or stretch a band, but scientists want one word for what these actions have in common. What should that word help us describe? What might we measure about a push or pull?

QUESTION 2

More than 2000 years ago, Aristotle argued that an object keeps moving only while something continues pushing it. Why would this fit ordinary experience? Describe a situation that seems to support the idea. What would you want to investigate before accepting it?

QUESTION 3



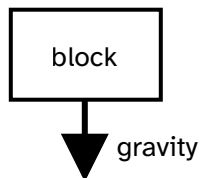
A box starts from rest. A push acts right for 1.0s. When the push ends, the box is moving right at 5.0m/s.

- a) What changed during the push?
- b) Determine the box's acceleration during the push.

b) 5.0m/s^2 right

QUESTION 4

student's diagram



A student draws this FBD for a block that is sitting still on the ground.

$F_N = mg$ **is not a general formula.**

- a) According to this diagram, what is the direction of F_{net} ? What acceleration does the diagram predict?
- b) The block is not accelerating. What force is missing? Add it to a corrected FBD.

a) net force down; acceleration down | b) normal force up

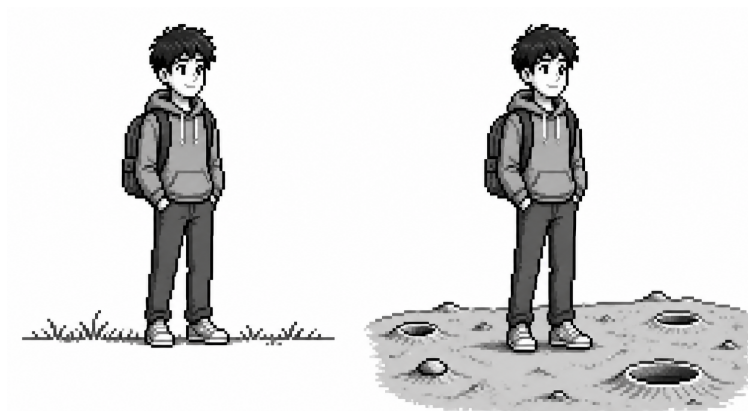
QUESTION 5

Use $F_{\text{net}} = ma$. In each situation, the stated force is the total horizontal force.

- a)** A 3.0kg cart accelerates right at 4.0m/s^2 . Determine the force.
- b)** An 18N force acts right on a 6.0kg cart. Determine the acceleration.
- c)** A 24N force accelerates a cart right at 2.0m/s^2 . Determine the mass.
- d)** A 5.0kg cart changes from 2.0m/s right to 8.0m/s right in 3.0s. Determine its acceleration and the force.

a) 12N right | **b)** 3.0m/s^2 right | **c)** 12kg | **d)** 2.0m/s^2 right; 10N right

QUESTION 6



Gravity is the force Earth or another world exerts on an object. Near a world's surface, its acceleration is g , so $F_g = mg$. The same 65kg student stands on Earth, where $g=9.8\text{N/kg}$, and on the Moon, where $g=1.6\text{N/kg}$.

- a) Determine the student's weight on Earth.
- b) Determine the student's weight on the Moon.
- c) State the student's mass on the Moon.
- d) The student did not lose any matter. Why did the weight change while the mass stayed the same?

a) 637N down | b) 104N down | c) 65kg

QUESTION 7

Someone says, “If $F_{\text{net}}=0$, the object must not be moving.” Sometimes that is true, but is that what the equation actually says? Use $F_{\text{net}}=ma$.

- a) If $F_{\text{net}}=0$, what must the acceleration be?
- b) Does zero acceleration mean zero velocity? If not, what does zero acceleration tell you about the velocity?
- c) Describe two possible motions of an object with zero net force.

a) 0m/s^2 | b) no; velocity remains constant | c) at rest; moving with constant nonzero velocity

QUESTION 8

A train moves right at 20m/s. Someone says, "Its velocity is right, so F_{net} must be right." What does the velocity tell you? What does it not tell you about F_{net} ? What else about its motion must you know?

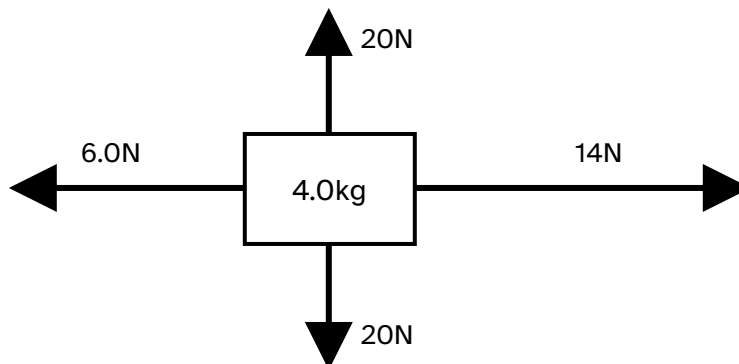
Net Force and Free-Body Diagrams

Name _____

Block _____

Date _____

QUESTION 1



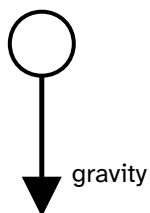
Four forces act on the same box. A student writes $F_{\text{net}} = 20\text{N} + 20\text{N} + 6.0\text{N} + 14\text{N} = 60\text{N}$ and says, "I added every force, so this must be the total."

- The student made two different mistakes. Find and explain both.
- Correct the calculation by finding the horizontal and vertical net forces separately. Use right and up as positive.
- Now state the rule properly: add forces with their directions, one axis at a time. The symbol Σ means add, so $F_{\text{net}} = \Sigma F = ma$. Determine the acceleration of the box.
- Suppose the 14N right force changes to 6.0N right. Determine the horizontal net force and acceleration.
- If the box in part d is already moving right, describe its motion after the forces become balanced.

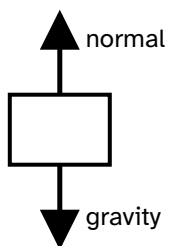
a) mixed the axes; ignored direction | **b)** 8.0N right; 0N vertical | **c)** 2.0m/s² right | **d)** 0N; 0m/s² | **e)** constant velocity right

QUESTION 2

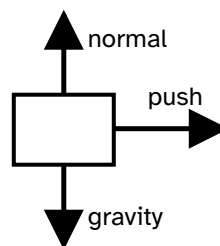
falling ball



book at rest



pushed box



State the direction of acceleration for each object and explain how you know.

falling ball: down; book: none; pushed box: right

QUESTION 3

For each situation, draw and label a free-body diagram.

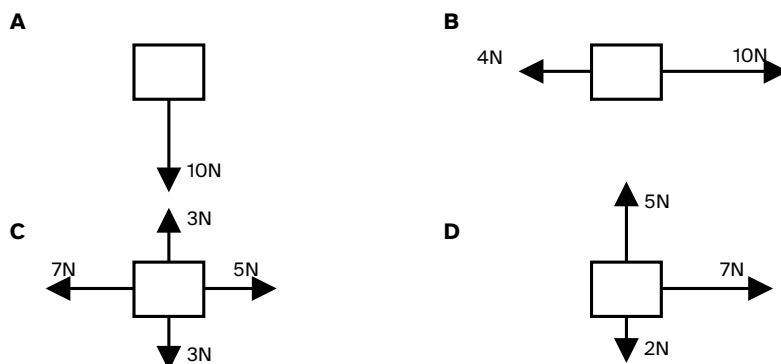
- a)** A student stands on level ground.
- b)** A box is pushed right across a frictionless floor.
- c)** A ball moves upward after leaving a hand.
- d)** A hand presses downward on a book resting on a table.

a) normal up, gravity down | **b)** normal up, gravity down, push right | **c)** gravity down | **d)** normal up, gravity down, hand force down

QUESTION 4

Two objects have identical free-body diagrams with zero net force. One object is sitting still. The other is moving right. Can both diagrams be correct? What can a free-body diagram tell you about an object? What can it not tell you?

QUESTION 5



For each free-body diagram, determine the net force in each direction and state the direction of acceleration.

- a) Diagram A
- b) Diagram B
- c) Diagram C
- d) Diagram D

a) 10N down; acceleration down | b) 6N right; acceleration right | c) 2N left; acceleration left | d) 7N right and 3N up; 7.6N at 23° above the horizontal; acceleration in the same direction

QUESTION 6

For each situation, draw a free-body diagram and use $F_{\text{net}} = \Sigma F = ma$ to determine the net force and acceleration.

- a)** A 4.0kg box is pushed with 20N right while another force acts with 8.0N left.
- b)** A 7.5kg box moves left while a 15N pull acts left and another force acts with 6.0N right.
- c)** A 6.0kg book has 58.8N of gravity down and a 58.8N normal force up.
- d)** A 3.0kg bucket has 24N of tension up and 29.4N of gravity down.

a) 12N right, 3.0m/s² right | **b)** 9N left, 1.2m/s² left | **c)** 0N, 0m/s² | **d)** 5.4N down, 1.8m/s² down

QUESTION 7

A 4.0kg cart is moving left. An 18N force acts right while a 6.0N force acts left. Determine the net force and acceleration. Then describe what happens to the cart's speed at first. Explain why its leftward velocity does not require a leftward net force.

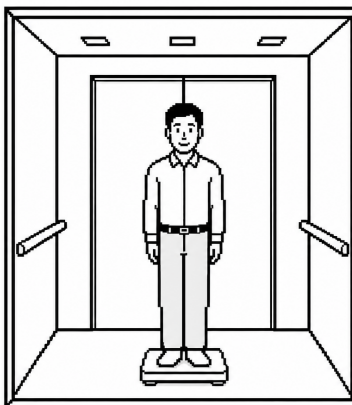
12N right; 3.0m/s^2 right; slows at first

Elevators and Apparent Weight

Name _____

Block _____

Date _____

QUESTION 1

You stand on a scale in an elevator. You have not gained or lost any matter, and gravity has not suddenly changed, but the number on the scale changes when the elevator starts or stops.

- a)** Draw your free-body diagram while the elevator is not moving.
- b)** Draw your free-body diagram while the elevator accelerates upward.
- c)** What do you notice? What do you wonder?

QUESTION 2

A scale measures the normal force it exerts on you. A 60kg passenger stands on a scale while the elevator accelerates upward at 0.80m/s^2 . Calculate the scale reading.

636N

QUESTION 3

A 70kg person stands on a scale in an elevator.

- a)** Determine the reading while the elevator is at rest.
- b)** Determine the reading while it accelerates upward at 0.70m/s^2 .
- c)** Determine the reading while it moves upward at constant velocity.
- d)** The elevator moves upward at 1.0m/s , then stops in 2.5s . Determine the reading while it slows.

a) 686N | **b)** 735N | **c)** 686N | **d)** 658N

QUESTION 4

Priya says, “If an elevator is moving upward, the scale must read more than her weight.” Explain why this is not always correct.

the scale reading depends on acceleration, not velocity; an elevator moving upward can have zero acceleration or accelerate downward

QUESTION 5

A 60kg passenger's scale reads 620N. Determine the passenger's acceleration.

0.53m/s² up

QUESTION 6

A 60kg passenger is moving downward while the scale reads 420N. Determine the acceleration, including direction. Is the passenger speeding up or slowing down?

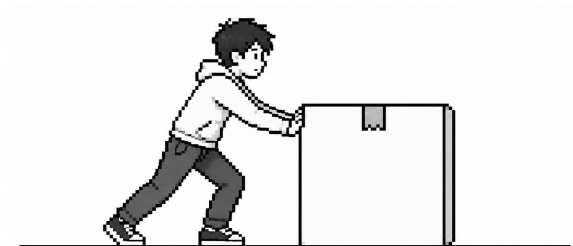
2.8m/s² down; speeding up

Friction

Name _____

Block _____

Date _____

QUESTION 1

In the past, people believed that an object could keep moving only while a force continued to push it. Why does this seem right? Describe a situation that appears to support the statement. Then explain why the statement is not correct and describe a situation that contradicts it.

QUESTION 2

A 20kg box slides right while pushed right with 150N. The coefficient of kinetic friction is 0.20.

- a)** Determine the friction force.
- b)** Determine the acceleration.

a) 39.2N left | **b)** 5.54m/s² right

QUESTION 3

A 300kg box at rest is pushed right with 2000N. The coefficients are $\mu_s=0.60$ and $\mu_k=0.30$.

- a)** Determine whether the box begins moving.
- b)** Determine its acceleration after it begins moving.

a) yes | **b)** 3.73m/s^2 right

QUESTION 4

A 6.0kg box slides along a level floor where $\mu_k=0.20$. Determine the applied force required to accelerate it right at 0.68m/s^2 .

15.8N right

QUESTION 5

A 15kg box is pushed horizontally right with 90N. It accelerates right at 3.1m/s^2 across a level floor. Determine the coefficient of kinetic friction.

0.30

QUESTION 6

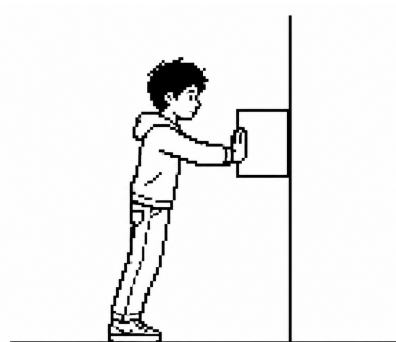
A student says, “Friction is always μF_N , and it always points opposite the applied force.” Explain why each part of this statement can fail.

QUESTION 7

A 10kg box remains at rest while pushed right with 50N. The coefficient of static friction is 0.80. What is the friction force in this situation? Are you sure? Does your answer make sense?

50N left

QUESTION 8

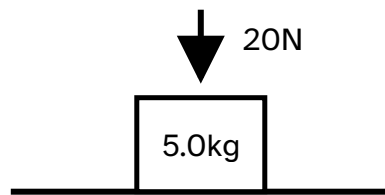


A 5.0kg box is pushed horizontally towards a wall and held in place. The coefficient of static friction between the box and the wall is 0.30.

- a)** Explain why the box does not fall.
- b)** Draw and label the free-body diagram.
- c)** Determine the minimum horizontal push required to keep the box in place.

a) static friction balances gravity | **b)** push right, normal left, friction up, gravity down | **c)** 163N

QUESTION 9



A 5.0kg box rests on a level floor. A student pushes straight down on it with a force of 20N. Determine the normal force exerted by the floor on the box.

69N up

Spring Force and Spring Constant

Name

Block

Date

QUESTION 1

A spring is stretched by 0.050m, 0.100m, and 0.150m. The required holding forces are 10N, 20N, and 30N.

- a)** Describe the relationship between force and extension.
- b)** Determine the force-to-extension ratio.
- c)** Predict the force at 0.120m.

a) constant ratio; force is proportional to extension | **b)** 200N/m | **c)** 24N

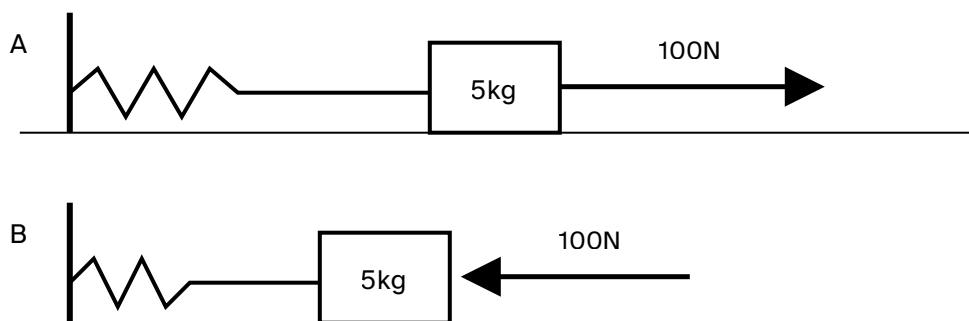
QUESTION 2

A 10kg box rests on a vertical spring with $k=200\text{N/m}$.

- a)** Draw the free-body diagram.
- b)** Determine the compression.

a) spring force up, gravity down | **b)** 0.490m

QUESTION 3



A 5.0 kg block is held at rest in each spring system shown. The spring constant is 250 N/m.

- Draw the free-body diagram for each held block.
- Determine the extension or compression in each system.
- Draw the free-body diagram immediately after each applied force is removed.
- Determine the initial acceleration after release in each system.

a) A: normal up, gravity down, spring left, applied right; B: normal up, gravity down, spring right, applied left | **b)** 0.40 m each | **c)** A: normal up, gravity down, spring left; B: normal up, gravity down, spring right | **d)** 20 m/s^2 left in A, right in B

QUESTION 4

Liam finds the spring force on a block 0.080m to the right of equilibrium.

Liam writes:

$$F_s = kx = (250\text{N/m})(0.080\text{m}) = +20\text{N}$$

- a) Identify what Liam did correctly.
- b) Explain the sign error.
- c) State the correct spring force.

c) 20N left

QUESTION 5

A 0.50kg block compresses a vertical spring from 50cm to 30cm and remains at rest.
Determine the spring constant.

24.5N/m

QUESTION 6

A spring produces forces of 6.0N, 12N, 18N, and 24N at extensions of 0.030m, 0.060m, 0.090m, and 0.120m. Determine the spring constant and predict the force at 0.085m.

200N/m, 17N

QUESTION 7

A 0.80kg block is released from rest while compressing a horizontal spring by 0.12m. The spring constant is 320N/m. Determine the block's initial acceleration.

48m/s²

One-Dimensional Forces Review

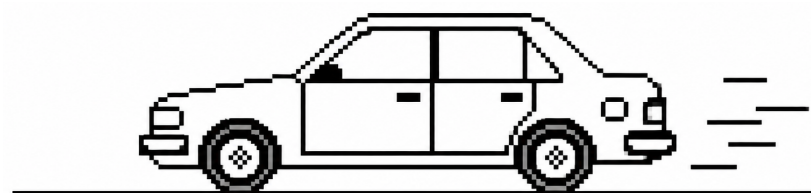
Name	Block	Date
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QUESTION 1

A 35kg crate slides right on a level floor. A 180N applied force acts right and 62N of kinetic friction acts left. Determine the acceleration.

3.37m/s² right

QUESTION 2



A 1200kg car moves left at constant velocity while its engine provides 900N left. A spectator says, “The engine force must be larger than the friction force because the car is moving left.” Explain the spectator’s mistake, then determine the friction force and net force.

900N right, 0N

QUESTION 3

A 68kg passenger stands on a scale in an elevator accelerating downward at 1.4m/s^2 . Determine the scale reading.

571N

QUESTION 4

A 16kg crate at rest is pushed right with 80N on a floor where $\mu_s=0.60$. Determine the friction force and acceleration.

80N left, 0m/s^2

QUESTION 5

A 3.0kg block is released while stretching a horizontal spring with $k=150\text{N/m}$ by 0.18m.
Determine its initial acceleration.

9.0m/s² inward

QUESTION 6

Owen analyzes a 12kg box with 70N right and 30N left.

He writes:

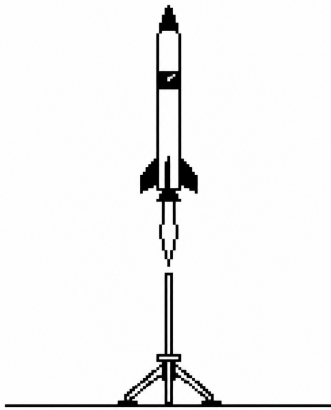
$$F_{\text{net}} = 70\text{N} + 30\text{N} = 100\text{N}$$

$$a = F_{\text{net}}/m = 8.3\text{m/s}^2 \text{ right}$$

- a) Identify what Owen did correctly.
- b) Explain the mistake.
- c) Determine the correct acceleration.

c) 3.3m/s^2 right

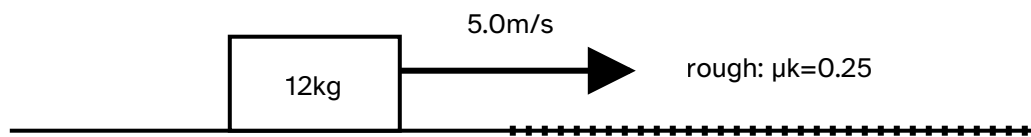
QUESTION 7



A 750kg rocket accelerates upward at 4.0m/s^2 . Determine the thrust force.

10350N up

QUESTION 8



A 12kg box moving right at 5.0m/s enters a rough floor where $\mu_k=0.25$. Determine the stopping distance.

5.10m

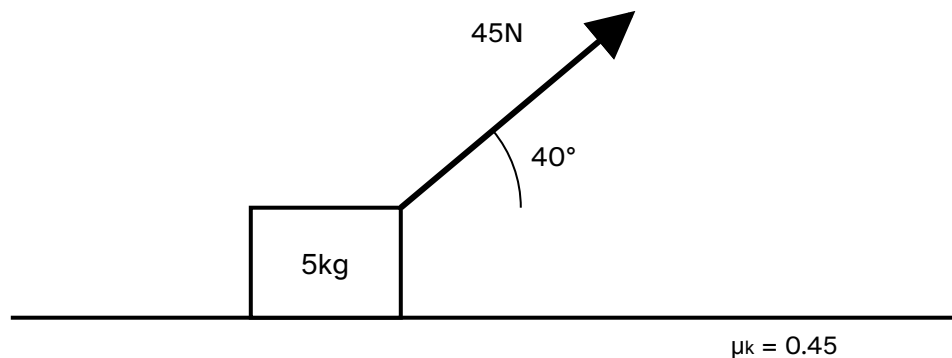
Angled Applied Forces

Name	Block	Date
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QUESTION 1

Two people pull identical boxes with equal forces. One pulls horizontally. The other pulls upward at an angle. Predict whether the pulls have the same horizontal effect and whether the boxes have the same normal force and friction. Explain why the force magnitude alone is insufficient.

QUESTION 2



The box is pulled as shown.

- a) Determine the horizontal component.
- b) Determine the vertical component.
- c) Determine the normal force.
- d) Determine the kinetic friction.
- e) Determine the acceleration.

a) 34.5N right | b) 28.9N up | c) 20.1N up | d) 9.04N left | e) 5.09m/s² right

QUESTION 3

A 5.0kg box is pushed with 50N at 30° below the horizontal. The coefficient of kinetic friction is 0.30. Determine the acceleration.

4.22m/s² right

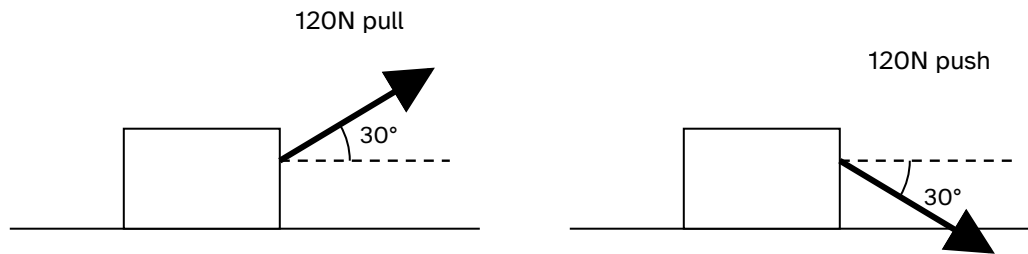
QUESTION 4

A student draws $F_N = mg$ for every box on a level floor. Explain why an angled pull or push can make this equation wrong even though the box has no vertical acceleration.

QUESTION 5

Pulling upward at an angle reduces the normal force but also reduces the horizontal part of the applied force. Explain why this means that increasing the angle does not automatically produce a larger acceleration.

QUESTION 6



If you wanted to make moving the crate easier, would you pull upward at an angle or push downward at the same angle? Explain.

pull upward; it reduces the normal force and friction

QUESTION 7

A 40kg crate is pulled at 25° above the horizontal across a floor where $\mu_k=0.30$. Determine the applied force required for an acceleration of 1.5m/s^2 right.

172N

QUESTION 8

A 20kg box is pulled right with 100N at 30° above the horizontal.
It accelerates right at 2.87m/s^2 . Determine the coefficient of kinetic friction.

0.20

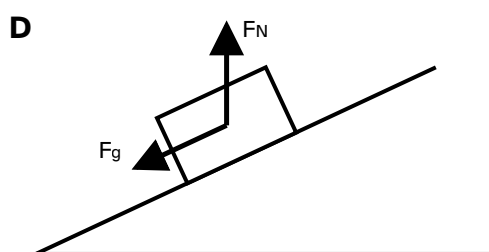
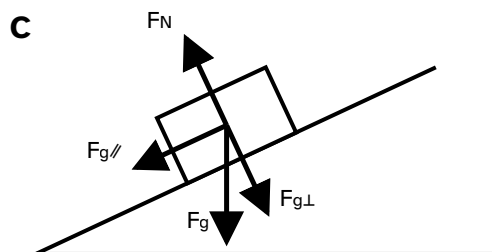
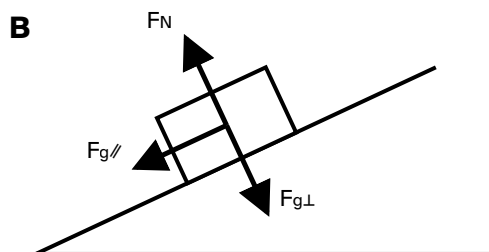
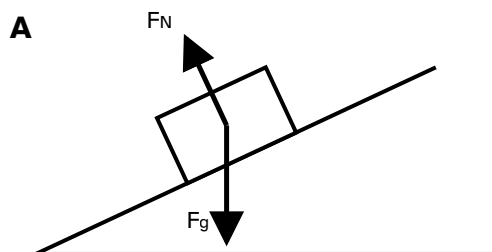
Inclined Planes

Name _____

Block _____

Date _____

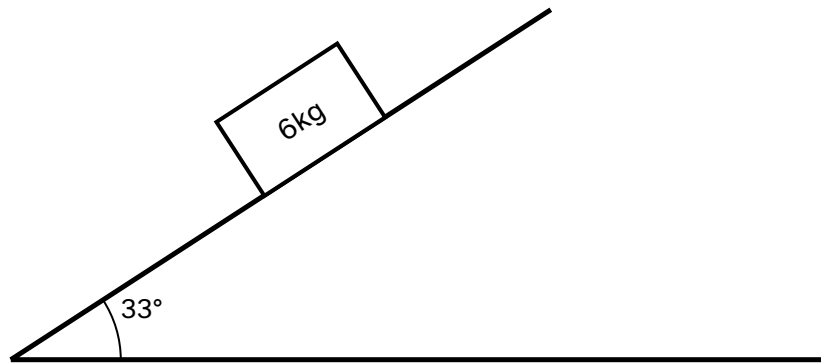
QUESTION 1



Diagrams A and B are correct. Explain why both representations are valid and why C and D are not.

A uses the full gravity force; B replaces gravity with its two components; C counts gravity twice; D gives gravity and the normal force incorrect directions

QUESTION 2



A 6.0kg block moves down the 33° ramp shown.

- a) Determine its acceleration if the ramp is frictionless.
- b) Determine its acceleration if $\mu_k=0.20$.

a) 5.34m/s^2 down | b) 3.69m/s^2 down

QUESTION 3

A 10kg block moves down a 40° ramp with an acceleration of 2.0m/s^2 . Determine the coefficient of kinetic friction.

0.573

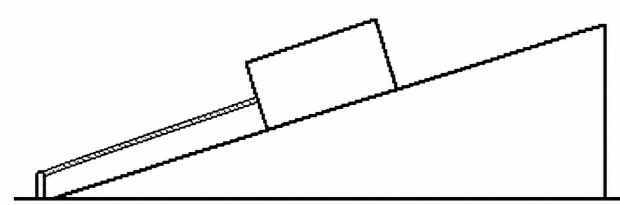
QUESTION 4

A 20kg block is placed at rest on a 25° ramp where $\mu_s=0.55$.

- a)** Determine whether the block begins to slide.
- b)** Determine the actual static friction force.

a) no; downhill gravity is 82.8N while maximum static friction is 97.7N | **b)** 82.8N up the ramp

QUESTION 5

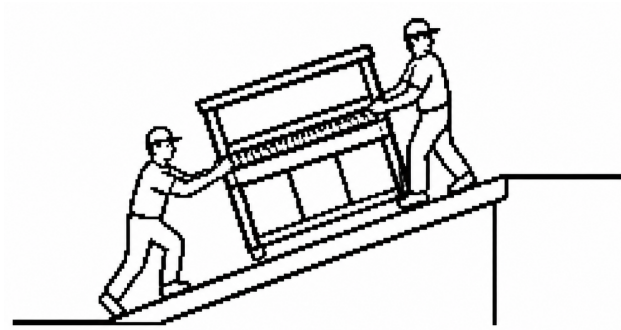


A 100kg box rests on a 20° ramp where $\mu_s=0.80$ and $\mu_k=0.50$. A rope pulls parallel to the ramp in the downhill direction.

- a)** Determine the force required to start the box moving downhill.
- b)** Once moving, determine the force required to maintain constant downhill velocity.

a) 402N down | **b)** 125N down

QUESTION 6



A 500kg piano is pushed up a 25° ramp where $\mu_k=0.25$.

- a) Determine the acceleration while a 4500N force pushes uphill.
- b) The push is removed and the piano slides back down. Determine the acceleration.

a) 2.64m/s^2 up | b) 1.92m/s^2 down

QUESTION 7

An 8.0kg block is pulled up a 25° ramp by an 80N force parallel to the ramp and accelerates at 4.53m/s^2 . Determine the kinetic friction force.

10.6N down the ramp

QUESTION 8

A 45kg crate slides down a 28° ramp at constant velocity. Determine the coefficient of kinetic friction.

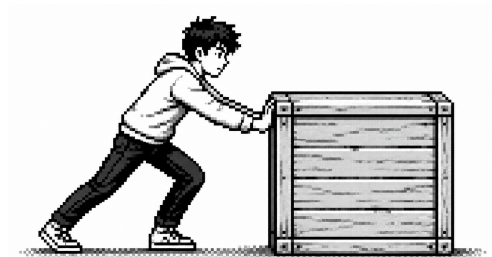
0.532

Multi-Body Systems and Newton's Third Law

Name _____

Block _____

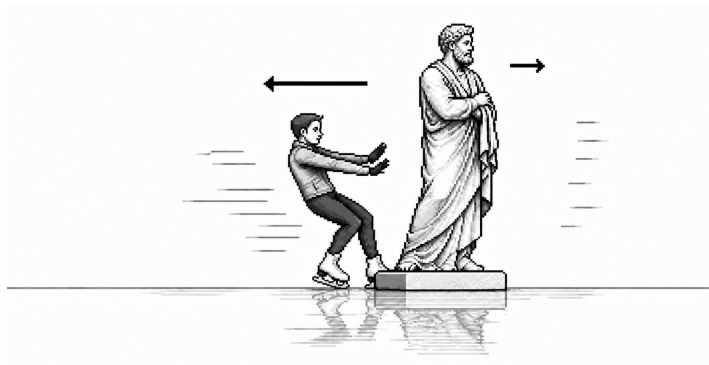
Date _____

QUESTION 1

Andy says, "If I push a block with 10N of force, the block pushes back on me with 10N. Those forces cancel, so the block cannot accelerate." What is wrong with Andy's reasoning?

the forces act on different objects, so they do not cancel on either object

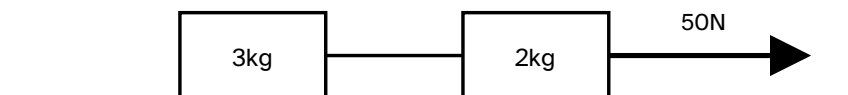
QUESTION 2



A 50kg skater and a 200kg statue are on frictionless ice. During a brief push, the skater exerts a 200N force on the statue to the right. The statue exerts a 200N force on the skater to the left. A student says, “Because the forces are equal, their accelerations must also be equal.” Explain the mistake. Calculate the acceleration of each object during the interaction, including direction.

the forces are equal and opposite, but they act on different masses; skater: 4.0m/s^2 left; statue: 1.0m/s^2 right

QUESTION 3

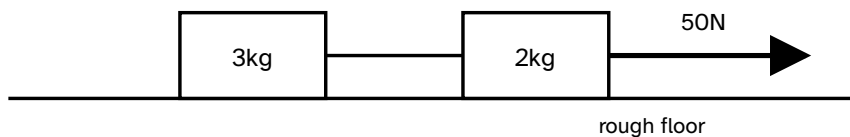


The connected blocks move on a frictionless floor as shown.

- a)** Draw free-body diagrams for each block and for the two-block system.
- b)** Determine the acceleration.
- c)** Determine the rope tension.

a) 3kg: tension right; 2kg: tension left and 50N right; system: 50N right | **b)** 10.0m/s^2 right | **c)** 30N

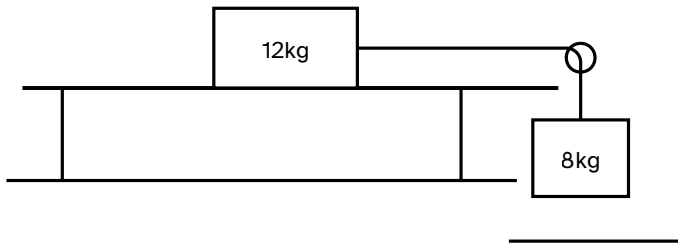
QUESTION 4



The 2.0kg and 3.0kg system from Question 3 is placed on a rough floor. The same 50N force pulls right, and the system accelerates at 6.0m/s^2 . Determine the coefficient of kinetic friction.

0.41

QUESTION 5

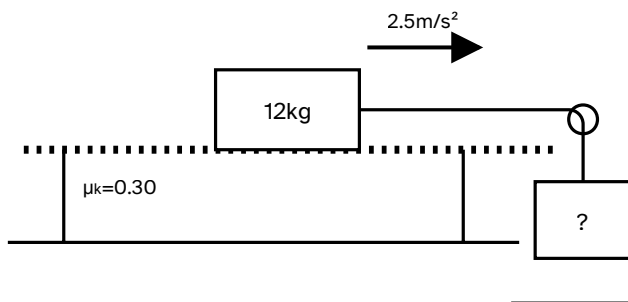


The connected system is shown. The table is frictionless.

- a) Determine the acceleration.
- b) Determine the rope tension.

a) 3.92m/s^2 | b) 47.0N

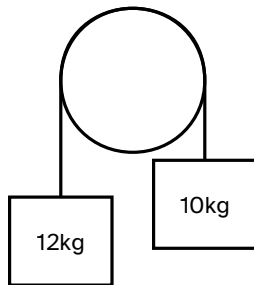
QUESTION 6



A 12kg block on a table where $\mu_k = 0.30$ is connected to an unknown hanging mass. The table block accelerates right at 2.5m/s^2 . Determine the hanging mass.

8.94kg

QUESTION 7

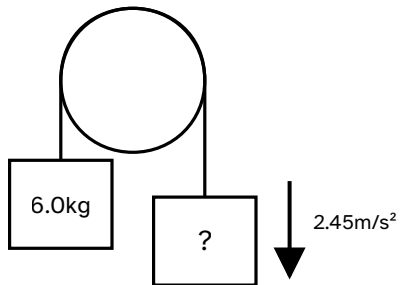


The Atwood machine is shown.

- a)** Determine the acceleration.
- b)** Determine the rope tension.

a) 0.891m/s^2 , 12kg down | **b)** 107N

QUESTION 8



An Atwood machine has a 6.0kg mass and an unknown heavier mass. The unknown mass accelerates downward at 2.45m/s^2 . Determine the unknown mass.

10.0kg

Kinetic, Potential, and Mechanical Energy

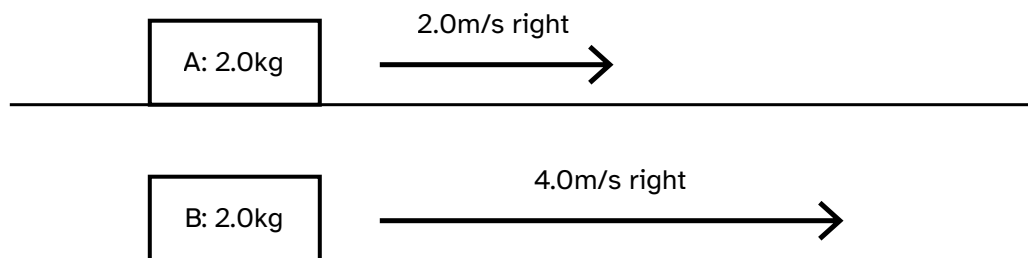
Name	Block	Date
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QUESTION 1

A younger student asks, “What are kinetic energy and gravitational potential energy?” Explain both without using equations. Use examples that make the difference clear.

kinetic energy is energy an object has because it is moving; gravitational potential energy is energy associated with its position relative to a chosen reference level

QUESTION 2

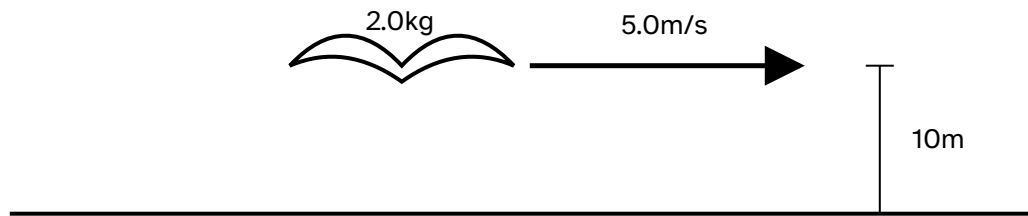


The two boxes are identical except for their speed.

- Before calculating, predict which box has more kinetic energy. Would doubling the speed merely double the kinetic energy?
- Calculate the kinetic energy of each box.

a) box B; more than twice | **b)** 4.0J, 16J

QUESTION 3



A 2.0kg bird flies at 5.0m/s while 10m above the ground. Use the ground as $h=0$. Calculate its kinetic energy, gravitational potential energy, and total mechanical energy.

25J, 196J, 221J

QUESTION 4

Bill is on the first floor of a building. John is on the second floor, where a box rests on the floor. John says the box has zero gravitational potential energy. Bill says it does not because it is above him. Who is right? Is there one right answer? Explain.

both can be right because gravitational potential energy depends on the chosen zero-height reference

QUESTION 5

A 2.0kg ball is dropped from 10m. Ignore air resistance and use the ground as $h=0$.

- a)** State the potential, kinetic, and total mechanical energy at release.
- b)** Determine those energies when the ball is 4.0m above the ground.
- c)** Determine its speed at that height.
- d)** Determine the three energies and speed just before impact.

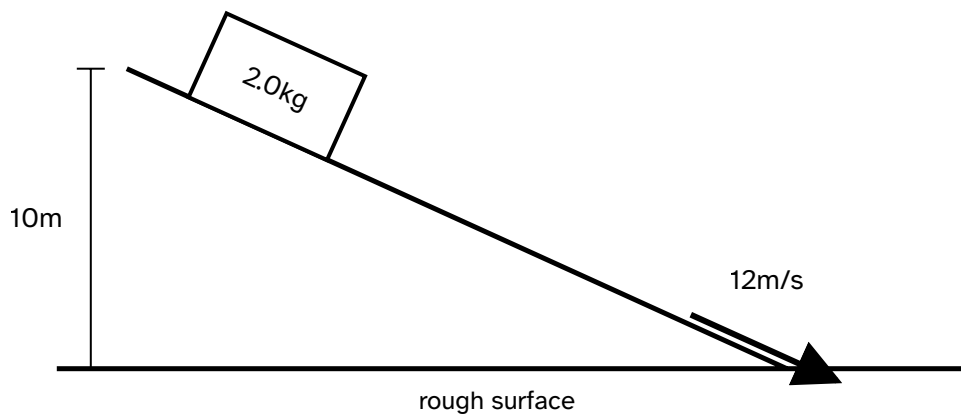
a) top: 196J, 0J, 196J | **b)** at 4.0m: 78.4J, 118J, 196J | **c)** 10.8m/s | **d)** ground: 0J, 196J, 196J; 14.0m/s

QUESTION 6

An object of unknown mass is dropped from 10m. Use conservation of mechanical energy to determine its impact speed and explain why the mass is not needed.

14.0m/s; mass cancels

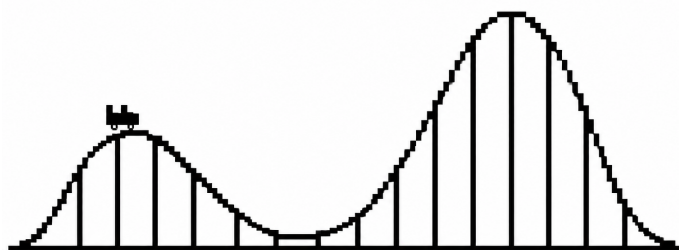
QUESTION 7



A 2.0kg box starts from rest 10m above the bottom of a rough ramp and reaches the bottom at 12m/s. Determine the initial and final mechanical energy, decide whether mechanical energy was conserved, and account for the difference.

196J, 144J; 52J transformed to thermal energy

QUESTION 8

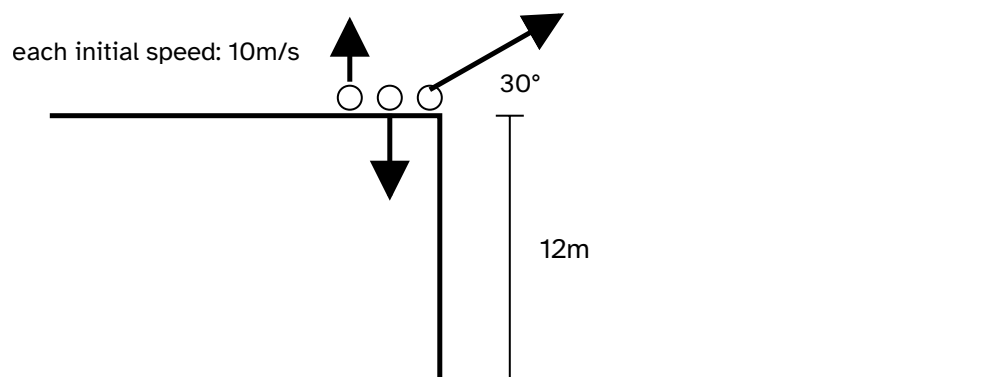


The roller coaster starts 5.0m above the ground and must pass over a 10m hill. Ignore friction.

- a) Determine the minimum initial speed needed to reach the top of the hill.
- b) Using that minimum initial speed, determine the speed at ground level after the hill.

a) 9.90m/s | b) 14.0m/s

QUESTION 9



Three identical balls leave the same 12m cliff at 10m/s . One is thrown upward, one downward, and one 30° above horizontal. Ignore air resistance. Predict and then determine their speeds at ground level. Explain the result.

18.3m/s each; equal initial mechanical energy

Introduction to Work

Name	Block	Date
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QUESTION 1

Work and energy both have units of joules. What is the difference between work and energy?
Use an example that clearly shows the difference.

energy is a property of a system; work is energy transferred when a force acts through a displacement

QUESTION 2

A 10kg box starts from rest and reaches 10m/s on a level floor.

- a)** Calculate the initial and final mechanical energy.
- b)** Where did the box's increase in energy come from?
- c)** Calculate the net work done on the box.

a) 0J, 500J | **b)** work transferred 500J to the box | **c)** 500J

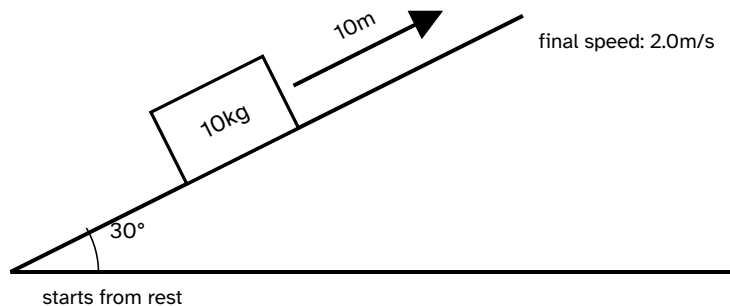
QUESTION 3

A 10kg box starts at ground level and is lifted 2.0m at constant speed.

- a)** Calculate the initial and final mechanical energy.
- b)** Calculate the work done on the box.

a) 0J, 196J | **b)** 196J

QUESTION 4



A 10kg box starts from rest and moves 10m up a frictionless 30° ramp. Its final speed is 2.0m/s. Calculate the work done by the applied force.

510J

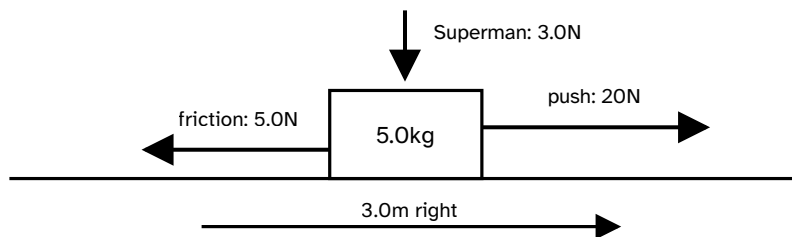
QUESTION 5

A constant net force F acts on a mass m in the direction of motion through a displacement d .

Use $F = ma$, $v_f^2 - v_i^2 = 2ad$, and $W_{net} = E_{Kf} - E_{Ki}$ to derive $W_{net} = Fd$.

$$W_{net} = \frac{1}{2}m(v_f^2 - v_i^2) = \frac{1}{2}m(2ad) = mad = Fd$$

QUESTION 6

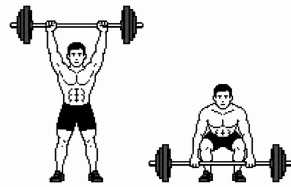


A 5.0kg box moves 3.0m right. A 20N push acts right, friction acts with 5.0N left, and Superman pushes down with 3.0N without changing the friction.

- a) Draw the free-body diagram.
- b) Calculate the work done by the push, friction, and Superman.
- c) Calculate the net work.
- d) Calculate the box's change in kinetic energy.

a) normal up, gravity down, Superman down, push right, friction left | b) +60J, -15J, 0J | c) +45J | d) +45J

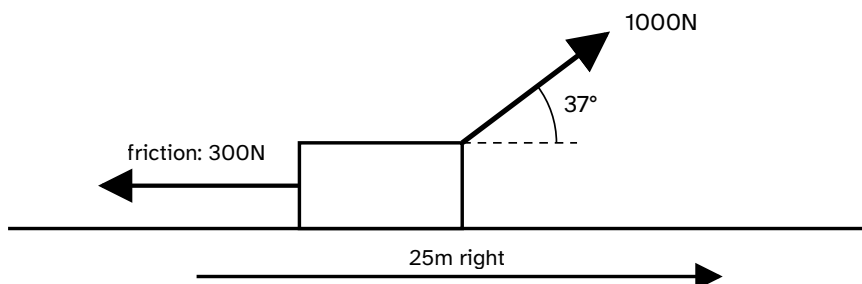
QUESTION 7



A weightlifter raises a 100kg barbell 2.0m at constant speed and then lowers it to the starting height at constant speed. Calculate the work done by the weightlifter during the lift, lowering, and complete trip.

+1960J, -1960J, 0J

QUESTION 8



A box moves 25m right while a 1000N applied force acts 37° above the horizontal and friction acts with 300N left.

- a) Resolve the applied force into horizontal and vertical components.
- b) Which component does work on the box?
- c) Which component does zero work on the box?
- d) Calculate the work done by the applied force.

a) 799N right, 602N up | b) horizontal component | c) vertical component | d) 20.0kJ

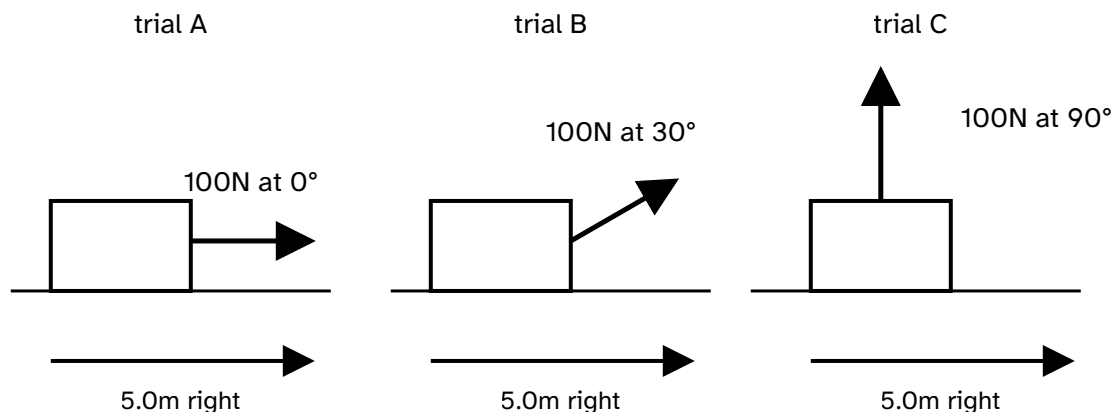
Work by Angled Forces

Name _____

Block _____

Date _____

QUESTION 1



Each box moves 5.0m right while a 100N force acts as shown.

- Before calculating, rank the work done by the force in the three trials.
- Determine the work done in each trial.
- Explain the pattern in the results.

a) $A > B > C$ | **b)** 500J, 433J, 0J | **c)** the component parallel to the displacement becomes smaller

QUESTION 2

Aaliyah is finding the work done by a 180N rope force that pulls a sled 40m horizontally. The rope is directed 35° above the horizontal.

Aaliyah writes:

$$W = Fd$$

$$W = (180\text{N})(40\text{m})$$

$$W = 7200\text{J}$$

- a) What did Aaliyah do correctly?
- b) Where does her reasoning become incorrect?
- c) Why might her approach have seemed reasonable to her?
- d) Correct Aaliyah's solution.

d) 5.90kJ

Elastic Potential Energy

Name	Block	Date
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QUESTION 1

A younger student asks how a compressed or stretched spring can store energy while it is not moving. Explain elastic potential energy without beginning with an equation.

QUESTION 2

The same spring is compressed 0.12m in one trial and stretched 0.12m in another.

- a)** Compare the elastic potential energy stored.
- b)** Compare the directions of the spring force.
- c)** Explain why the two comparisons are different.

a) equal | **b)** opposite directions | **c)** energy depends on x^2 ; force depends on the sign of x

QUESTION 3

A spring with $k=400\text{N/m}$ is compressed by 0.20m .

- a)** Determine the spring-force magnitude.
- b)** Determine the elastic potential energy stored.

a) 80N | **b)** 8.0J

QUESTION 4

Theo calculates the energy stored in the spring from Question 3.

Theo writes:

$$E_e = \frac{1}{2}kx$$

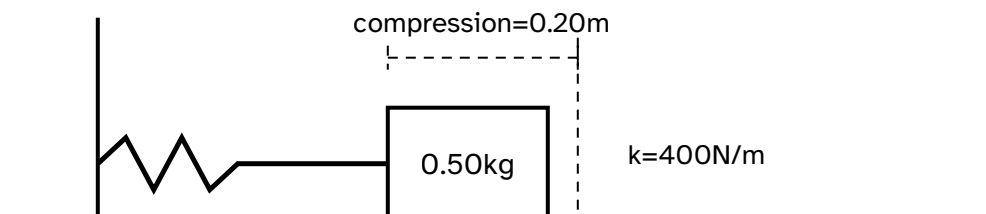
$$E_e = \frac{1}{2}(400\text{N/m})(0.20\text{m})$$

$$E_e = 40\text{J}$$

- a) What did Theo do correctly?
- b) Where does his reasoning become incorrect?
- c) Why might his approach have seemed reasonable to him?
- d) Correct Theo's solution.

d) 8.0J

QUESTION 5



The 0.50kg cart is released from the compressed spring shown on a frictionless floor.

- a)** Determine the initial elastic potential energy.
- b)** Determine the cart's kinetic energy when the spring reaches its natural length.
- c)** Determine the cart's speed at that instant.

a) 8.0J | **b)** 8.0J | **c)** 5.66m/s

QUESTION 6

A 0.40kg cart moving at 6.0m/s compresses a spring with $k=300\text{N/m}$ by 0.18m before stopping. Determine the energy transformed to thermal energy.

2.34J

QUESTION 7

A 2.0kg box moving at 4.0m/s compresses a spring with $k=250\text{N/m}$ on a frictionless floor.
Determine the maximum compression.

0.358m

QUESTION 8

A spring is compressed twice as far in a second trial. Predict how its stored energy and the launch speed of the same box change. Explain before calculating.

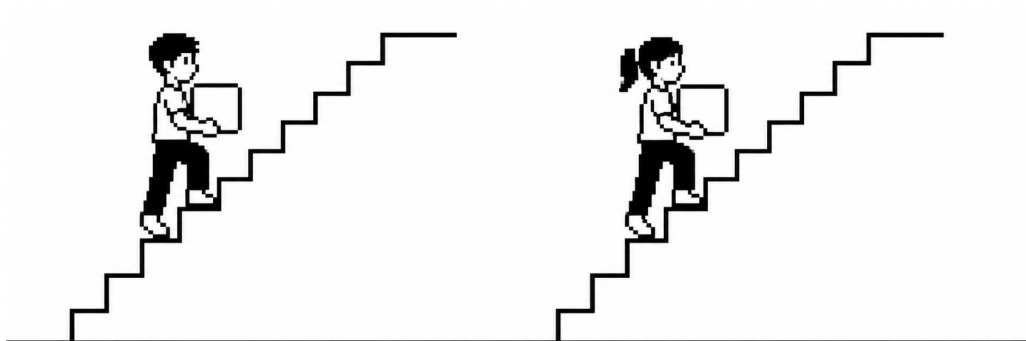
energy quadruples; launch speed doubles

Power and Efficiency

Name _____

Block _____

Date _____

QUESTION 1

Ava and Noah each carry the same 20kg box up 3.0m of stairs. Ava takes 6.0s and Noah takes 12s.

- a) Before calculating, compare the work each person does.
- b) Before calculating, compare their average power.
- c) Determine the work done by each person.
- d) Determine each person's average power.

a) same | b) Ava | c) 588J each | d) 98W, 49W

QUESTION 2

A younger student asks, "What is the difference between work and power?" Explain the difference using an example other than Question 1.

work is energy transferred by a force through a displacement; power is the rate at which that work is done

QUESTION 3

A common misconception is: “A more powerful machine always uses more energy.” Why might someone believe this? Give a situation in which it is false.

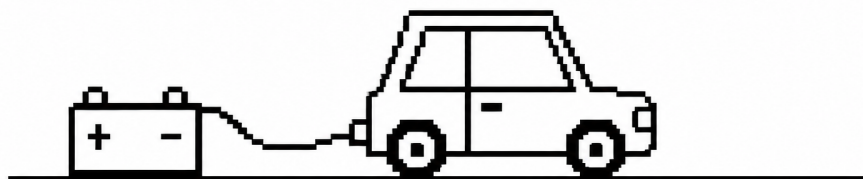
power describes energy transferred per unit time; a lower-power machine can use more total energy by operating longer

QUESTION 4

A 50kg box accelerates from rest to 3.5m/s in 5.0s. Determine the work done and the average power.

306J, 61.3W

QUESTION 5



A 10kg toy car uses 30J of electrical energy to accelerate from rest to 2.5m/s.

- a) State the energy input.
- b) Determine the kinetic-energy output.
- c) Calculate the efficiency.
- d) Explain what the result reveals.

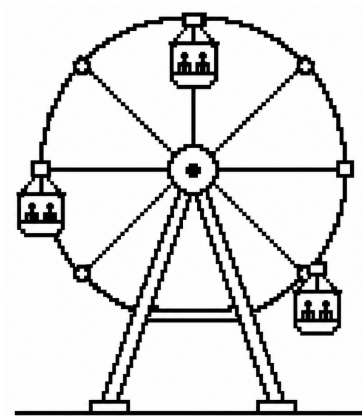
a) 30J | b) 31.3J | c) 104%; impossible | d) at least one measurement or assumption is wrong

QUESTION 6

A toy crane draws 30W while lifting a 1.5kg mass 2.5m in 4.0s. Determine its input energy, output power, and efficiency.

120J, 9.19W, 30.6%

QUESTION 7



A Ferris wheel uses 40.0kJ to raise passengers 18.2m and is 65% efficient. Determine the total passenger mass.

146kg

QUESTION 8

A car receives an average input power of 71.4kW. Its efficiency is 35%. Calculate the output power.

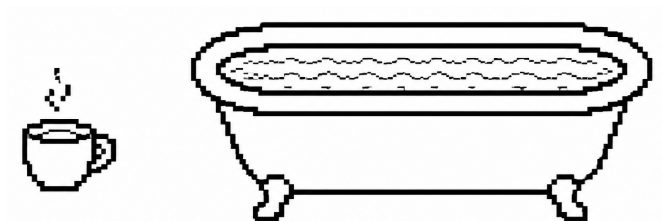
25.0kW

Thermal Energy and Heat

Name _____

Block _____

Date _____

QUESTION 1

A 0.25kg cup of water is at 80°C while a 150kg bathtub of water is at 35°C. Which has the higher temperature? Which contains more thermal energy? Explain why those are different questions.

cup has higher temperature; bathtub has more thermal energy

QUESTION 2

A younger student asks, “What is the difference between temperature and thermal energy?”
Explain using an example.

temperature describes how hot or cold an object is; thermal energy also depends on how much material is present and what it is made of

QUESTION 3

A common misconception is: “The object with the higher temperature must contain more thermal energy.” Why might someone believe this? What important information is missing?

temperature is easy to compare, but thermal energy also depends on mass, material, and state

QUESTION 4

Heat is thermal energy transferred because of a temperature difference. Water has a specific heat capacity of $4200\text{J}/(\text{kg}\cdot^{\circ}\text{C})$.

- a)** Determine the heat required to warm 1.0kg of water by 1.0°C .
- b)** Determine the heat required to warm 0.50kg of water from 25°C to 80°C .
- c)** A kettle uses 200kJ to cause that temperature change. Determine its efficiency.

a) 4200J | **b)** 116kJ | **c)** 57.8%

QUESTION 5

You run cold water over a hot pan. Someone says, “The water is transferring the cold into the pan.” What is incorrect about this statement?

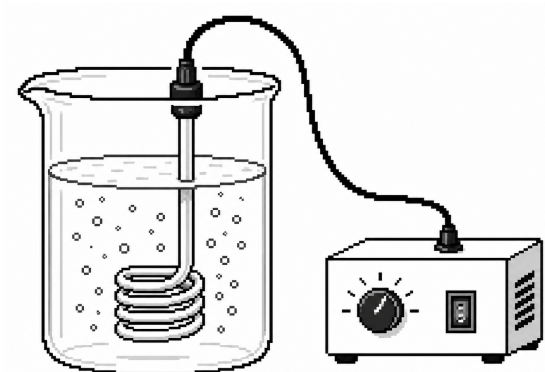
heat transfers from the hotter pan to the colder water

QUESTION 6

A 0.75kg aluminum pan with $c=900\text{J}/(\text{kg}\cdot^{\circ}\text{C})$ warms from 20°C to 180°C . Determine the heat transferred to the pan.

108kJ

QUESTION 7



A 1000W water heater operates for 5.0min at 45% efficiency. It warms water from 10°C to 65°C. Determine the mass of water heated.

0.584kg

QUESTION 8

A 60W heater transfers heat to a 0.40kg liquid with $c=2400\text{J}/(\text{kg}\cdot^{\circ}\text{C})$ for 8.0min. Assume no energy is lost. Determine the temperature increase.

30.0°C

Mixed Energy Problems

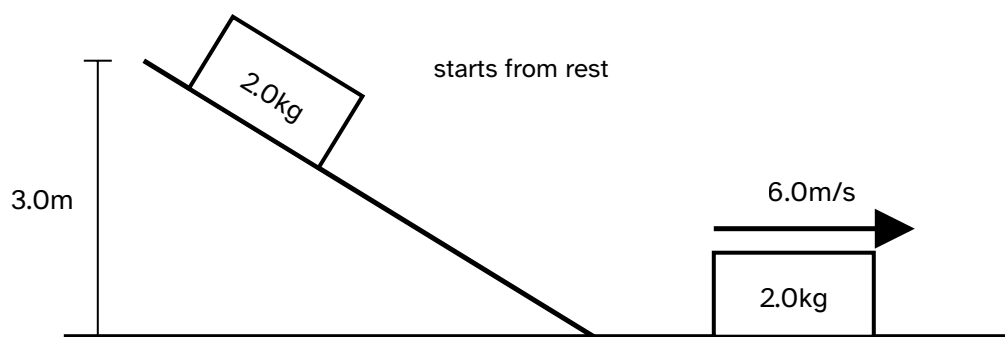
Name	Block	Date
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QUESTION 1

An electric motor lifts a crate while the motor becomes warmer. Describe the energy transfers, identify the output energy, and explain where power and efficiency enter the description.

electrical energy becomes gravitational potential energy and thermal energy; the gravitational potential energy is the output, power is the rate of transfer, and efficiency compares output energy or power with input energy or power

QUESTION 2



A 2.0kg box starts from rest and slides down from a height of 3.0m. Its speed at the bottom is 6.0m/s.

- a) Determine the initial mechanical energy.
- b) Determine the final mechanical energy.
- c) Determine the energy transformed to thermal energy.

a) 58.8J | b) 36.0J | c) 22.8J

QUESTION 3

A 5.0kg box starts at 10m/s and slides down through a vertical height of 3.0m. Its specific heat capacity is 200J/(kg·°C), and its temperature rises by 0.10°C. Determine its speed at the bottom.

10.9m/s

QUESTION 4

A motor uses 4000J of electrical energy to lift a 15kg crate through 20m. During the lift, the 4.0kg motor with $c=500\text{J}/(\text{kg}\cdot^{\circ}\text{C})$ warms from 22°C to 22.5°C . Determine the lifting efficiency and account for the measured motor heating.

73.5% lift, 25.0% thermal, 1.5% other

QUESTION 5

A motor receives 2.0kW of input power and is 75% efficient. Determine its output power.

1.5kW

QUESTION 6

An electric lifting motor receives 1.5kW of input power for 12s and is 60% efficient. It lifts an 80kg load. What height does the load reach?

13.8m

Charge and Current

Name	Block	Date
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QUESTION 1

Electric charge is a measurable property of matter. Electrons have negative charge and can move through a metal wire. In your own words, distinguish electric charge from electric current.

charge is the property carried by particles; current is how much charge passes a point each second

QUESTION 2

Current is the amount of charge passing a point each second. Use $I = \frac{Q}{t}$ and **1A=1C/s**.

- a) 12C of charge passes a point in 3.0s. Calculate the current.
- b) A wire carries 2.5A for 4.0s. Calculate the charge that passes.
- c) 18C passes a point while the current is 3.0A. Calculate the time.

a) 4.0A | b) 10C | c) 6.0s

QUESTION 3

Wire A carries 12C past a point in 3.0s. Wire B carries 18C past a point in 6.0s. Which wire has the greater current? Calculate both currents to check.

A: 4.0A; B: 3.0A; wire A

Current, Voltage, and Resistance

Name	Block	Date
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QUESTION 1

A disconnected 9V battery has no current. After a bulb is connected, the same current enters and leaves the bulb even though the bulb transfers energy to the surroundings. Explain why these observations require current and voltage to describe different things. Why can charge keep moving without being used up?

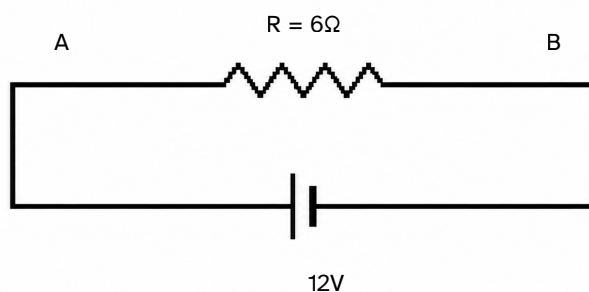
QUESTION 2

In a temporary model, people moving around a circuit represent charge. The number of people passing a point each second represents current. A battery gives each person money, and circuit components are places where that money is transferred.

- a)** What physical quantity is represented by the money each person receives?
- b)** What conservation rule is represented by people never appearing or disappearing?
- c)** Use the model to explain why current and voltage are not the same quantity.

a) voltage | **b)** charge is conserved

QUESTION 3



The circuit contains one 12V battery and one 6Ω resistor. In the model, each person receives \$12 from the battery, and the resistor is the only place to spend it.

- a)** How much money must each person spend at the resistor?
- b)** Translate that result into the voltage decrease across the resistor.
- c)** Use $V=IR$ to determine the circuit current.
- d)** If the current at A is 2.0A, determine the current at B.

a) \$12 | **b)** 12V | **c)** 2.0A | **d)** 2.0A

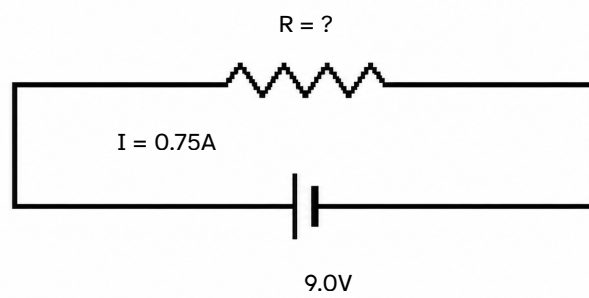
QUESTION 4

Continue with the circuit in Question 3.

- a)** Find the voltage increase across the battery.
- b)** Find the voltage decrease across the resistor.

a) 12V | **b)** 12V

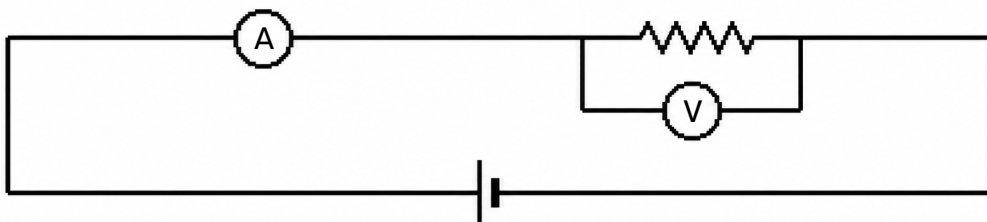
QUESTION 5



A resistor has $9.0V$ across it and carries $0.75A$. Determine its resistance.

12Ω

QUESTION 6



Use the meter arrangement shown.

- a)** Explain why the ammeter is connected in series with the resistor.
- b)** Explain why the voltmeter is connected across the resistor. Use the fact that voltage is a difference between two points.
- c)** A 10Ω resistor is connected to a 3.0V cell. Predict both meter readings.

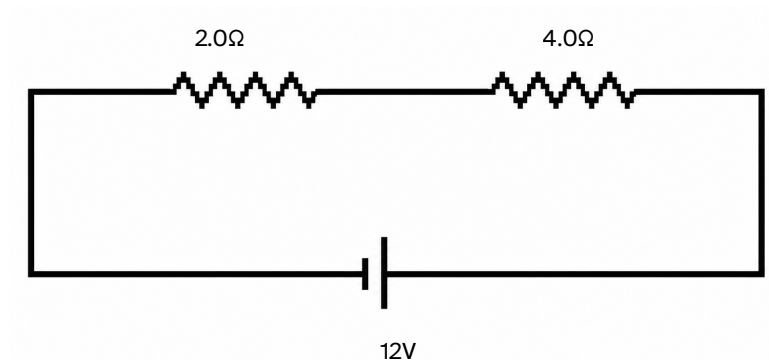
c) 0.30A , 3.0V

Series Circuits

Name _____

Block _____

Date _____

QUESTION 1

The 12V circuit has one path containing 2.0Ω and 4.0Ω resistors. In the people-and-money model, everyone must pass through both stores.

- a)** Compare the current through the two resistors.
- b)** State what the two voltage decreases must add to.
- c)** Must the two resistors have equal voltage decreases? Explain.

a) same current | **b)** 12V | **c)** no

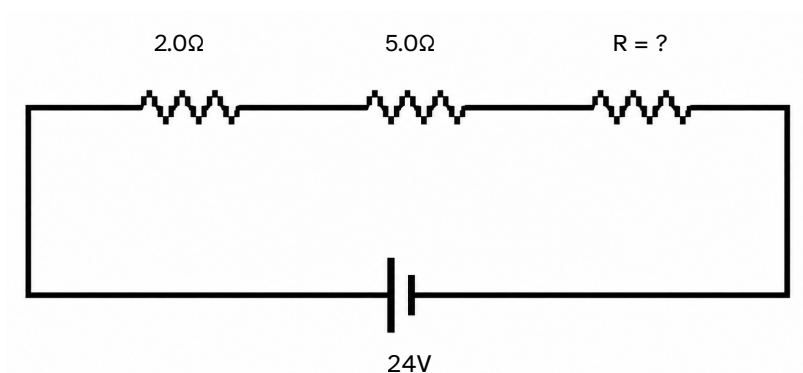
QUESTION 2

Replace the two resistors in Question 1 with one equivalent resistor that draws the same current from the same battery.

- a)** Determine the equivalent resistance.
- b)** Explain why replacing the pair with one resistor makes the circuit easier to solve.
- c)** Determine the circuit current.
- d)** Return to the original circuit and determine both voltage decreases.
- e)** Find the total voltage decrease across both resistors.

a) 6.0Ω | **c)** 2.0A | **d)** 4.0V , 8.0V | **e)** 12V

QUESTION 3



A 24V battery is connected to 2.0Ω , 5.0Ω , and an unknown resistor in series. The circuit current is 1.6A.

- a) Determine the total resistance.
- b) Determine the unknown resistance.
- c) Determine the voltage decrease across each resistor.
- d) Determine the total voltage decrease across all three resistors.

a) 15Ω | b) 8.0Ω | c) 3.2V, 8.0V, 12.8V | d) 24V

QUESTION 4

A 9.0V battery is connected to 100Ω , 220Ω , and 330Ω resistors in series. Determine the circuit current and the voltage across each resistor.

13.8mA; 1.38V, 3.05V, 4.57V

QUESTION 5

A 12V series circuit carries 0.50A. One resistor is 8.0Ω . Determine the other resistance and its voltage decrease.

16 Ω , 8.0V

QUESTION 6

A student needs 3.0V across a 150Ω sensor from a 9.0V supply using one series resistor.
Determine the required resistance.

300 Ω

QUESTION 7

Samira analyzes a 12V series circuit containing 4.0Ω and 8.0Ω resistors. She correctly finds a total resistance of 12Ω and a circuit current of 1.0A. She then splits the current equally, assigning 0.50A to each resistor and voltage decreases of 2.0V and 4.0V.

- a)** Identify what Samira did correctly.
- b)** Identify her first physical mistake and explain why it may have seemed reasonable.
- c)** Correct the resistor currents and voltage decreases.

a) 12Ω and 1.0A | **b)** current does not split in one path | **c)** 1.0A each; 4.0V and 8.0V

QUESTION 8

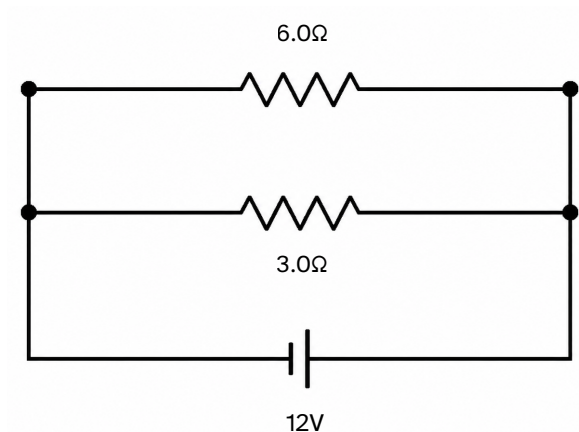
A third resistor is added in series while the battery voltage stays fixed. Predict what happens to the equivalent resistance and battery current. Explain the prediction using $V=IR$ and the fact that the circuit still has one path.

Parallel Circuits

Name _____

Block _____

Date _____

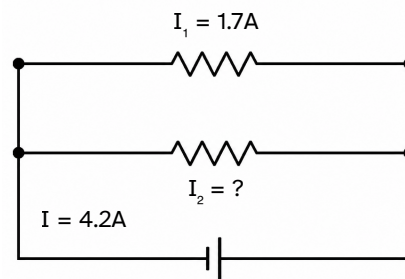
QUESTION 1

A 12V battery is connected across 6.0Ω and 3.0Ω parallel branches. In the people-and-money model, some people take each path, but every person begins and ends at the same two points.

- a)** Determine each branch's voltage.
- b)** Determine both branch currents.
- c)** Determine the battery current.
- d)** Determine the equivalent resistance connected to the battery.

a) 12V each | **b)** 2.0A, 4.0A | **c)** 6.0A | **d)** 2.0Ω

QUESTION 2



The battery current is 4.2A. The upper parallel branch carries 1.7A, and the lower branch carries I.

a) Determine I.

a) 2.5A

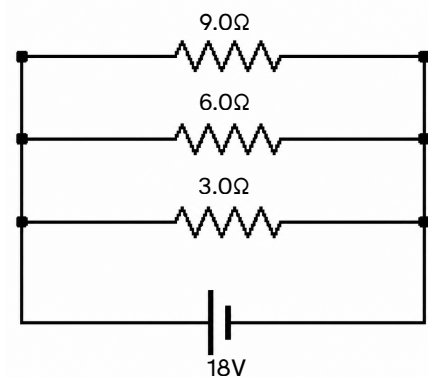
QUESTION 3

Mateo says the 12V battery in Question 1 must split equally, giving 6V to each parallel resistor. Why might that idea seem reasonable? Explain why it is wrong, then state the correct branch voltages.

- a)** Explain the misconception using the two possible paths.
- b)** State the correct voltage across each branch.

b) 12V each

QUESTION 4

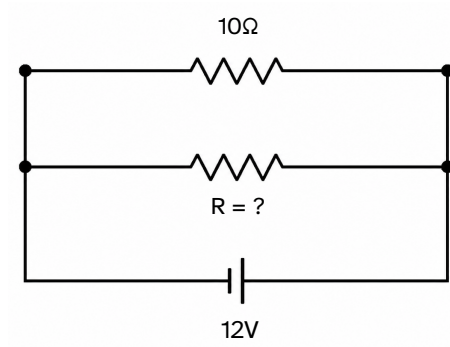


Resistors of 9.0Ω , 6.0Ω , and 3.0Ω are connected in parallel across 18V.

- a)** Determine each branch current.
- b)** Determine the battery current.
- c)** Determine the equivalent resistance.
- d)** Determine the current through all three resistors together.

a) 2.0A, 3.0A, 6.0A | **b)** 11A | **c)** 1.64Ω | **d)** $11A = 2.0A + 3.0A + 6.0A$

QUESTION 5



Two branches are connected across a 12V battery. One branch is 10Ω and the battery current is 5.0A.

- a) Determine the current in the 10Ω branch.
- b) Determine the other branch current.
- c) Determine the other branch resistance.

a) 1.2A | b) 3.8A | c) 3.16Ω

QUESTION 6

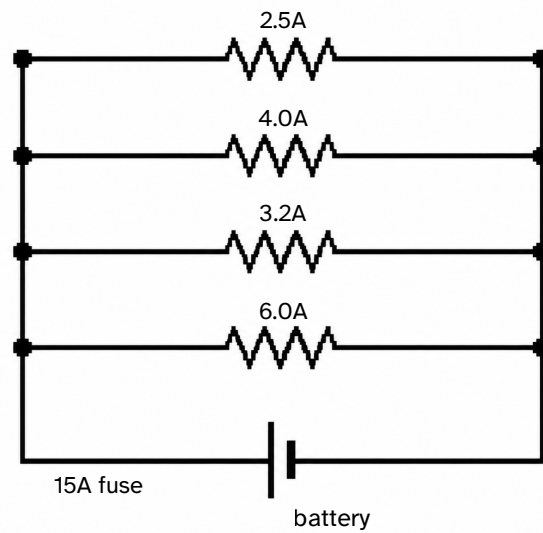
Three identical 30Ω resistors are connected in parallel to a 12V battery. Determine the current in each branch, the battery current, and the equivalent resistance.

0.40A each; 1.2A; 10Ω

QUESTION 7

Adding a parallel branch makes the equivalent resistance smaller than the smallest branch resistance. Explain how this can happen even though no resistor changes. Predict what happens to the battery current when the battery voltage remains fixed.

QUESTION 8



A 15A fuse supplies four parallel devices drawing 2.5A, 4.0A, 3.2A, and 6.0A.

- Determine the fuse current.
- Determine whether the fuse opens.
- Determine how far the current exceeds its rating.

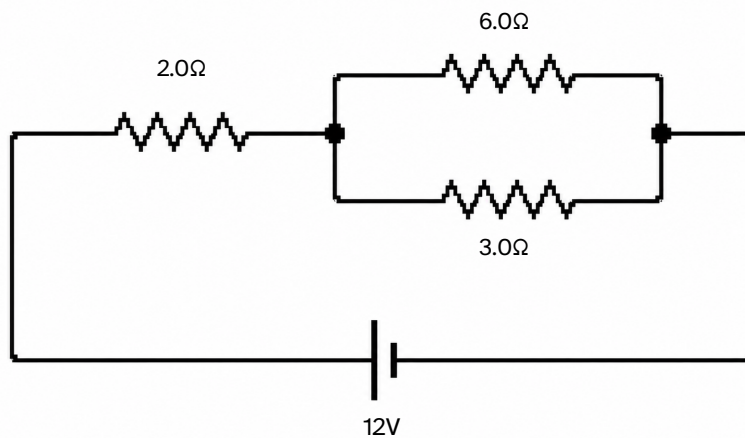
a) 15.7A | **b)** yes | **c)** 0.70A

Combined Series-Parallel Circuits

Name _____

Block _____

Date _____

QUESTION 1

Use the combined circuit shown.

- a)** Determine the equivalent resistance of the parallel section.
- b)** Determine the total circuit resistance.
- c)** Determine the battery current.
- d)** Determine the voltage across the 2.0Ω resistor.
- e)** Determine the voltage across the 6.0Ω resistor.
- f)** Determine the voltage across the 3.0Ω resistor.
- g)** Determine the current through the 6.0Ω resistor.
- h)** Determine the current through the 3.0Ω resistor.

a) 2.0Ω | **b)** 4.0Ω | **c)** 3.0A | **d)** 6.0V | **e)** 6.0V | **f)** 6.0V | **g)** 1.0A | **h)** 2.0A

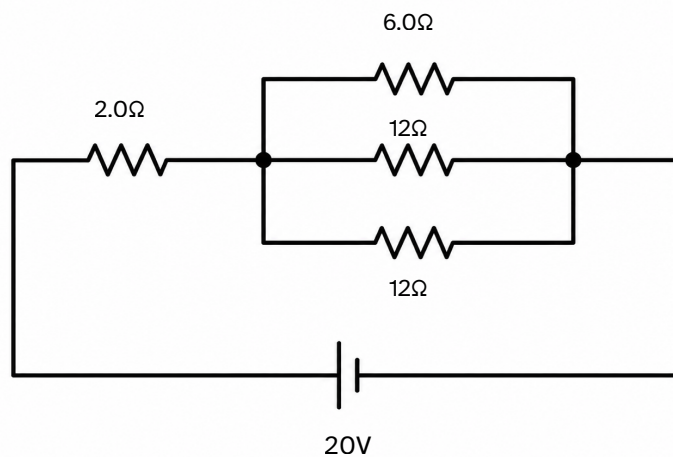
QUESTION 2

Maya combines the 6.0Ω and 3.0Ω branch resistors in Question 1 by adding them to get 9.0Ω .

- a)** Explain what feature of the circuit shows that this is wrong.
- b)** Determine the correct equivalent resistance of that section.

b) 2.0Ω

QUESTION 3



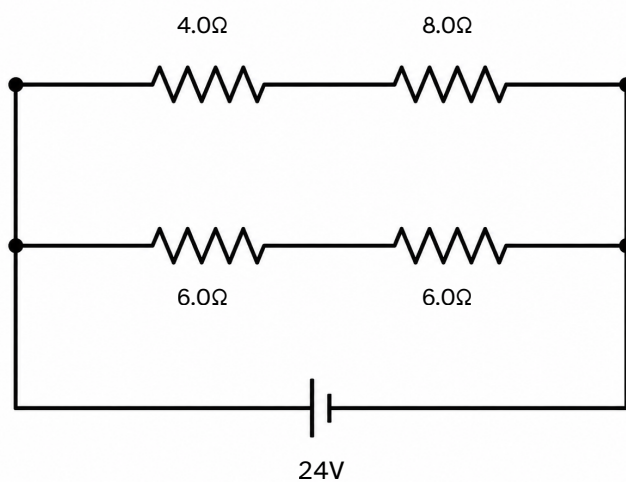
A 20V battery is connected to a 2.0Ω resistor in series with three parallel resistors of 6.0Ω , 12Ω , and 12Ω . Determine the total current, the parallel-section voltage, and every branch current.

4.0A total; 12V parallel; 2.0A, 1.0A, 1.0A

QUESTION 4

Before calculating a combined circuit, explain how you decide which resistors share the same current, which share the same voltage, and where the current must split or rejoin.

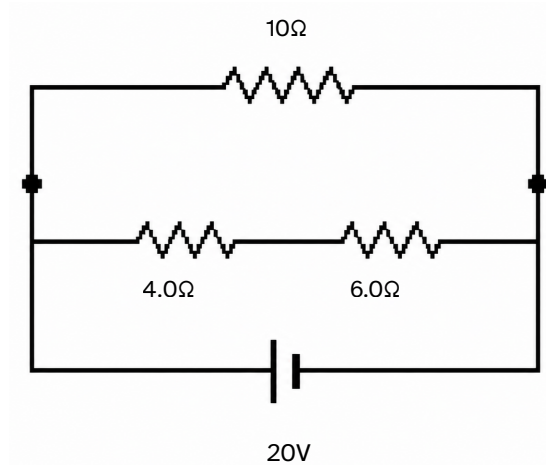
QUESTION 5



A 24V battery is connected to two parallel branches. The upper branch contains 4.0Ω and 8.0Ω resistors in series. The lower branch contains two 6.0Ω resistors in series. Determine the battery current, every resistor current, and every resistor voltage.

4.0A battery; 2.0A each branch; 8.0V, 16V, 12V, 12V

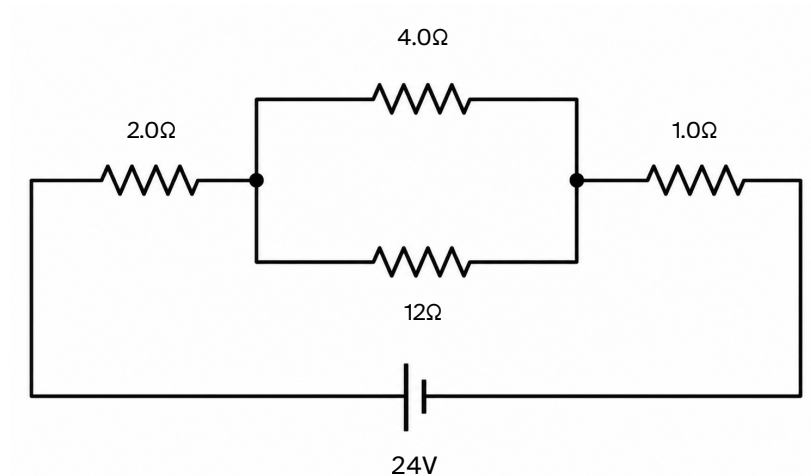
QUESTION 6



A circuit has a 10Ω resistor in parallel with a series pair of 4.0Ω and 6.0Ω . The network is connected across 20V. Determine the battery current and every resistor current.

4.0A total; 2.0A each branch

QUESTION 7



A 24V battery is connected to a 2.0Ω series resistor, then a parallel pair of 4.0Ω and 12Ω , then a 1.0Ω series resistor after the branches rejoin. Determine every resistor current and voltage.

4.0A battery; series drops 8.0V, 4.0V; branches 3.0A, 1.0A at 12V

EMF, Terminal Voltage, and Internal Resistance

Name

Block

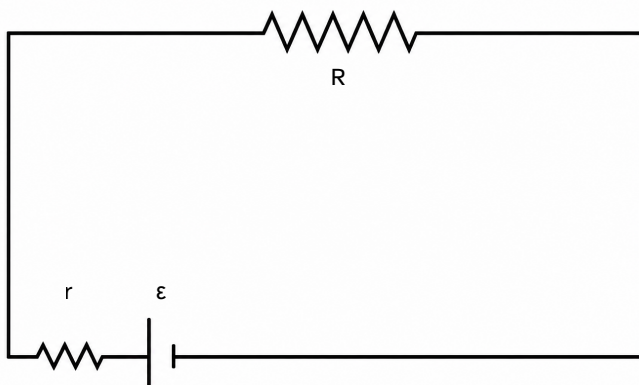
Date

QUESTION 1

Nina says, “Once a battery has internal resistance, the old series-circuit rules and $V=IR$ no longer apply. I should only use the new terminal-voltage formula.” What is wrong with Nina’s reasoning?

internal resistance is an ordinary series resistance; the same series rules and $V=IR$ still apply

QUESTION 2

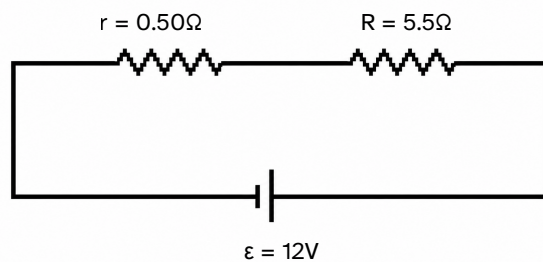


A battery with emf ϵ and resistor r is connected to resistor R .

- b)** Find the current through r .
- c)** Find the voltage consumed by r .
- d)** How much voltage is remaining right after r ? This is the terminal voltage. Look at the terminal voltage formula. The formula should make sense. There is no new physics - only new names.

b) $\epsilon/(R+r)$ | **c)** Ir | **d)** $V_{\text{terminal}} = \epsilon - Ir$

QUESTION 3



A 12V battery has resistor $r=0.50\Omega$ and is connected to resistor $R=5.5\Omega$.

- a) Determine the total circuit resistance.
- b) Determine the current.
- c) Determine the voltage across r .
- d) Determine the terminal voltage and the voltage across R .

a) 6.0Ω | b) $2.0A$ | c) $1.0V$ | d) $11V$

QUESTION 4

A battery has emf 12.0V and terminal voltage 11.4V while supplying 3.0A. Determine its internal resistance.

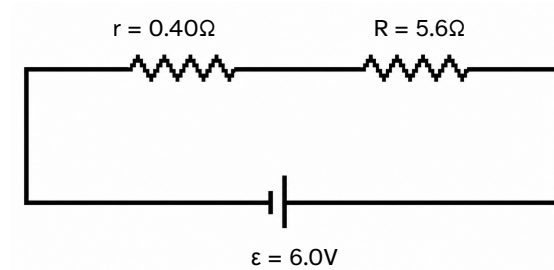
0.20 Ω

QUESTION 5

What is a short circuit? Why is it dangerous?

a direct, very low-resistance connection between battery terminals; it causes very large current and dangerous heating

QUESTION 6



A 6.0V battery has internal resistor $r=0.40\Omega$ and is connected to resistor $R=5.6\Omega$. Determine the current and terminal voltage.

1.0A, 5.6V

QUESTION 7

A 9.0V battery has a terminal voltage of 8.4V while connected to a 14Ω resistor. Determine the current and internal resistance.

0.60A, 1.0Ω

QUESTION 8

A student says, “A dead battery must have zero emf.” Explain why a battery can still show a voltage with almost no current but fail when connected to a resistor that draws a large current.

with almost no current, Ir is very small; with greater current, the voltage decrease across the internal resistor is larger

QUESTION 9

Two batteries have the same emf. Battery A has greater internal resistance than battery B. Compare their terminal voltages when they supply the same current and explain.

A has lower terminal voltage

Electrical Power, Energy, and Efficiency

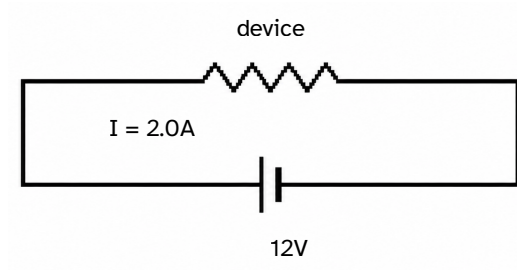
Name	Block	Date
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QUESTION 1

A phone charger and a microwave each transfer 60kJ of electrical energy. The charger takes several hours while the microwave takes one minute. Someone says the devices are “equally powerful” because they transferred equal energy. Decide whether that claim is reasonable. Use the situation to explain the difference between electrical energy and electrical power.

the claim is not reasonable; power is energy transferred per unit time, so the microwave has greater power because it transfers the same energy in less time

QUESTION 2

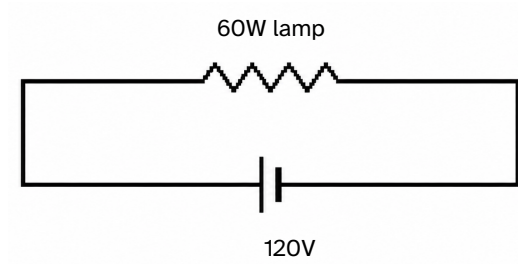


A device operates at 12V and draws 2.0A for 5.0min.

- a) Determine the electrical power.
- b) Determine the electrical energy used.

a) 24W | b) 7.2kJ

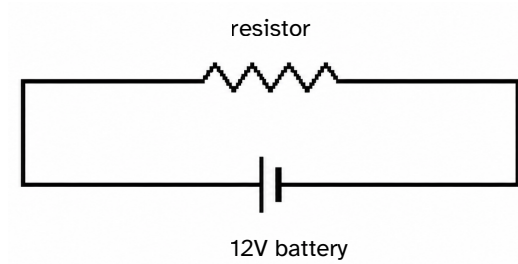
QUESTION 3



A 60W lamp operates at 120V. Determine its current and resistance.

0.50A, 240 Ω

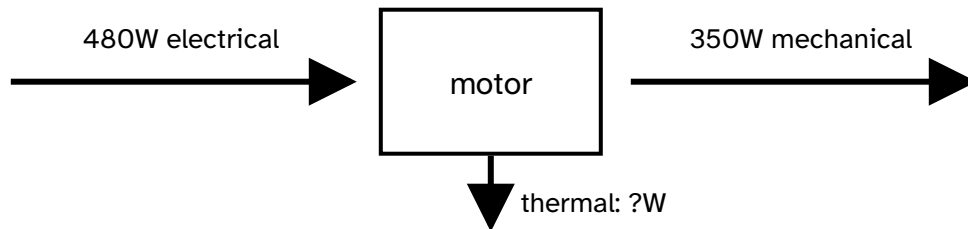
QUESTION 4



A 12V battery is rated at 50A·h. Estimate the stored energy in watt-hours and joules.

600Wh, 2.16MJ

QUESTION 5



An electric motor draws 480W and delivers 350W of mechanical power. Determine its efficiency and the rate of thermal-energy production.

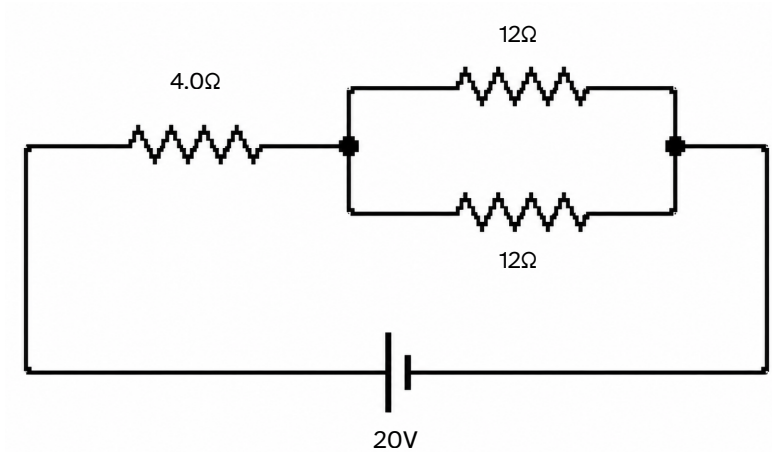
72.9%, 130W

QUESTION 6

A 1200W kettle heats 1.0kg of water from 20°C to 70°C in 3.0min. Use $c=4200\text{J}/(\text{kg}\cdot^{\circ}\text{C})$.
Determine the electrical input energy and the efficiency.

216kJ, 97.2%

QUESTION 7



A 20V battery is connected to a 4.0Ω resistor in series with two 12Ω resistors in parallel. Determine the total power, the power in the 4.0Ω resistor, and the power in each 12Ω resistor.

40W total; 16W; 12W each