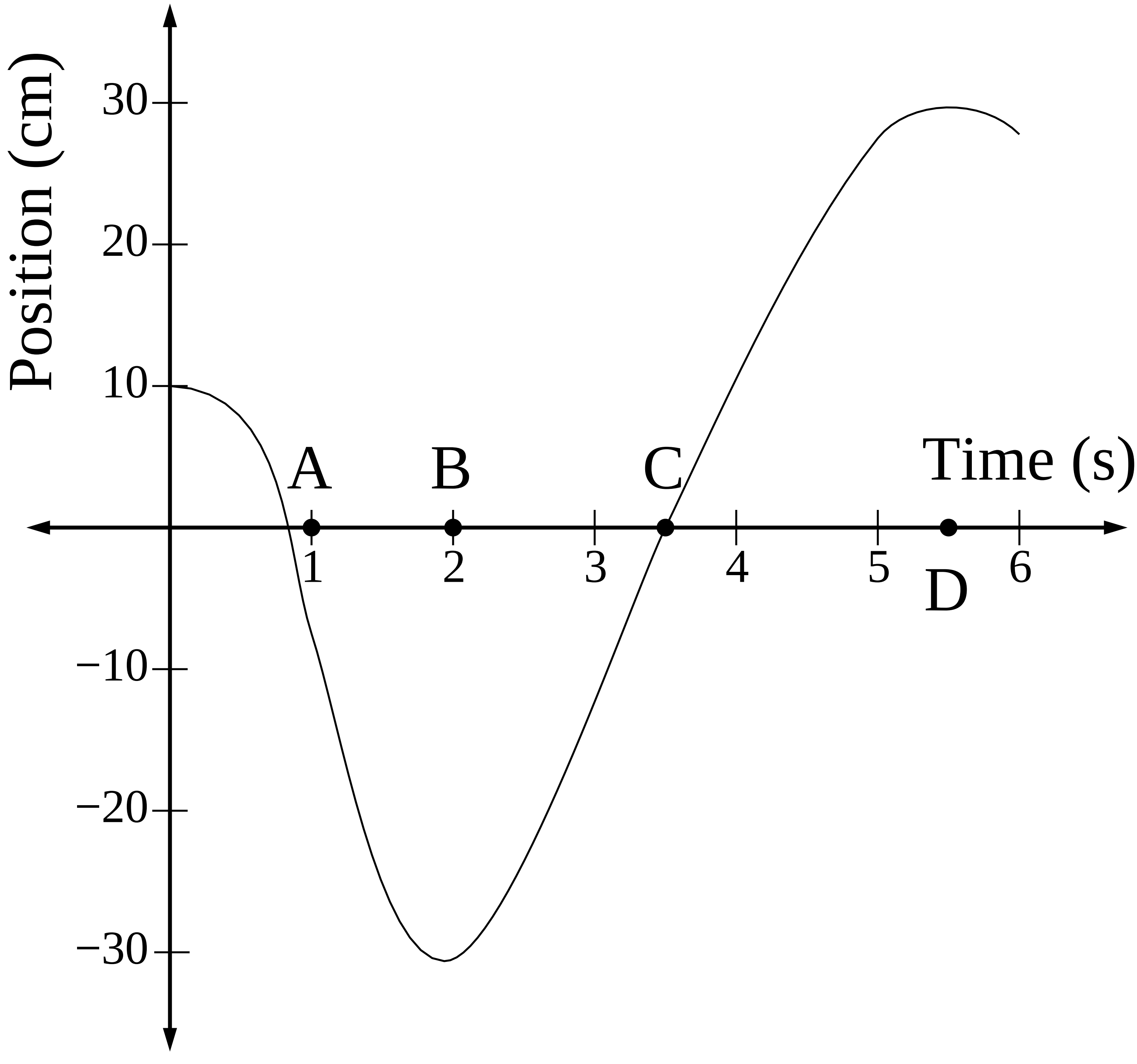
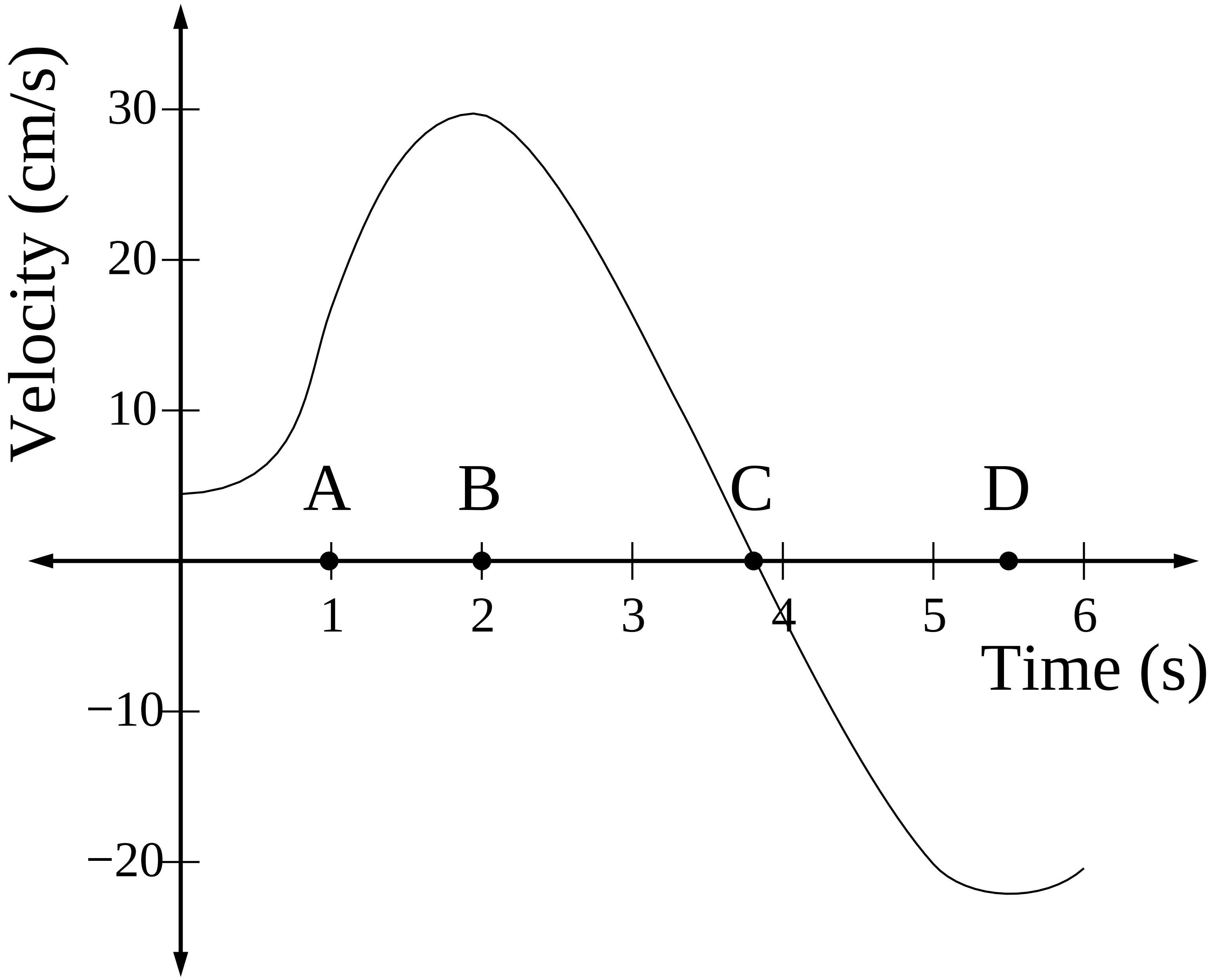
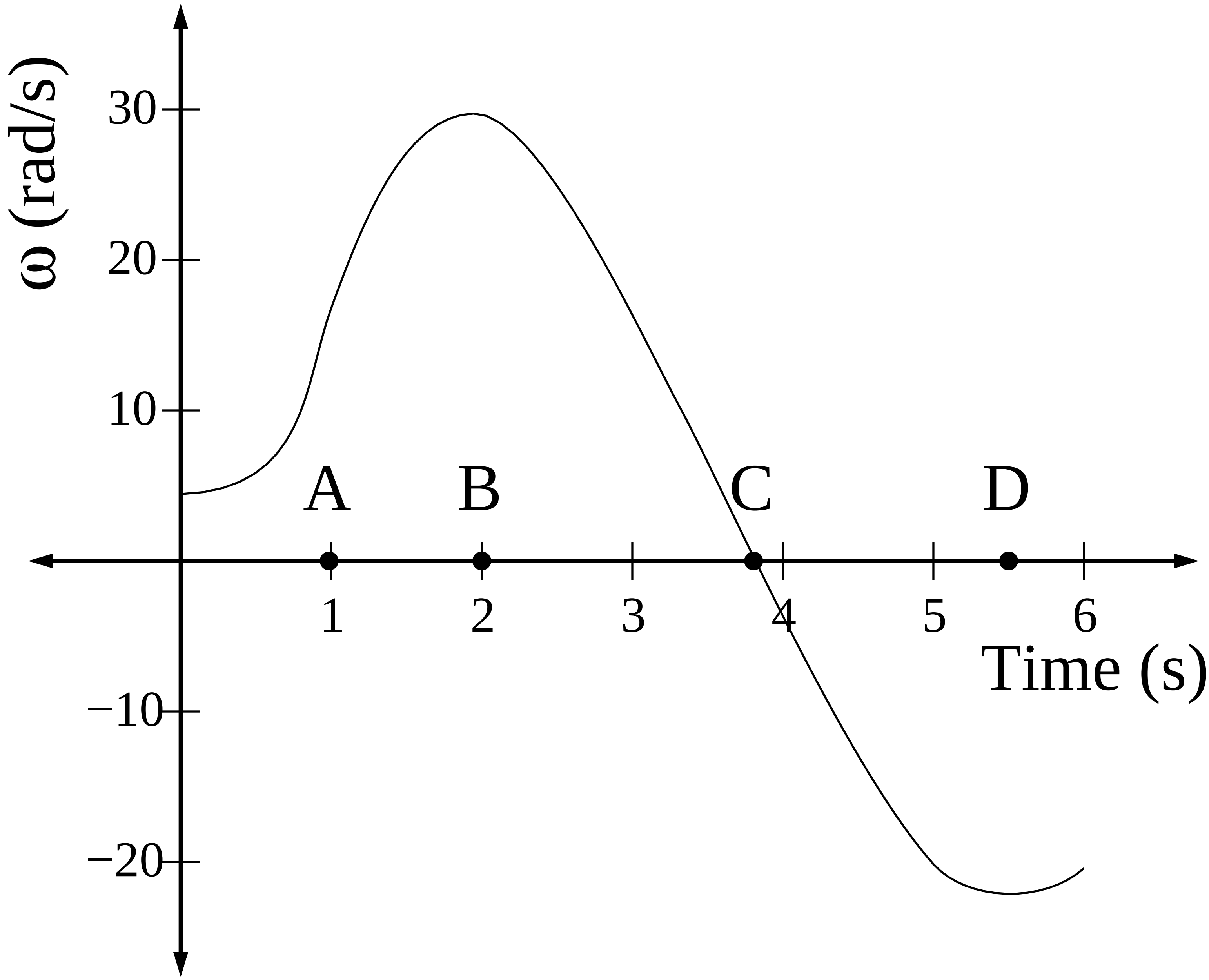
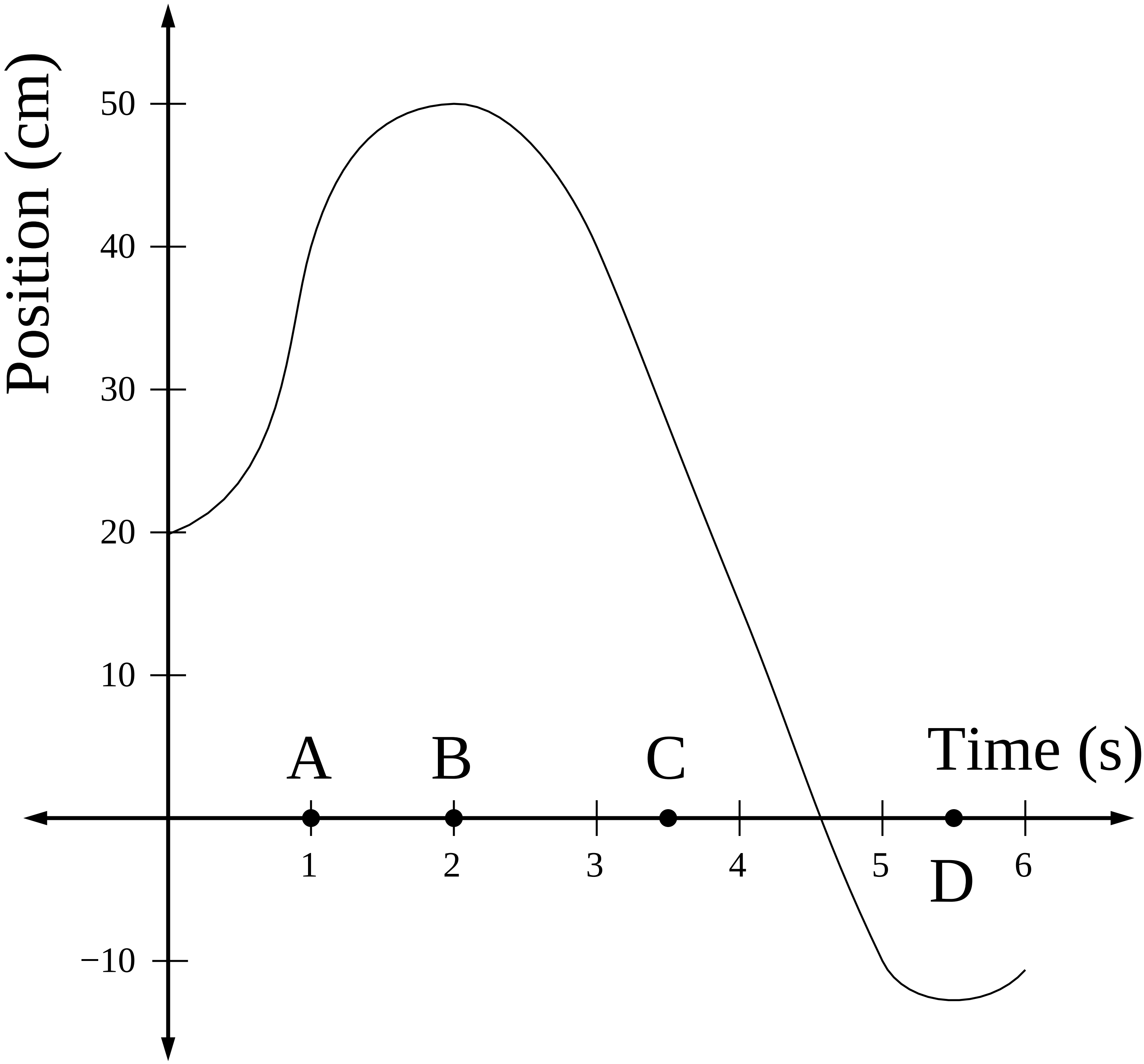
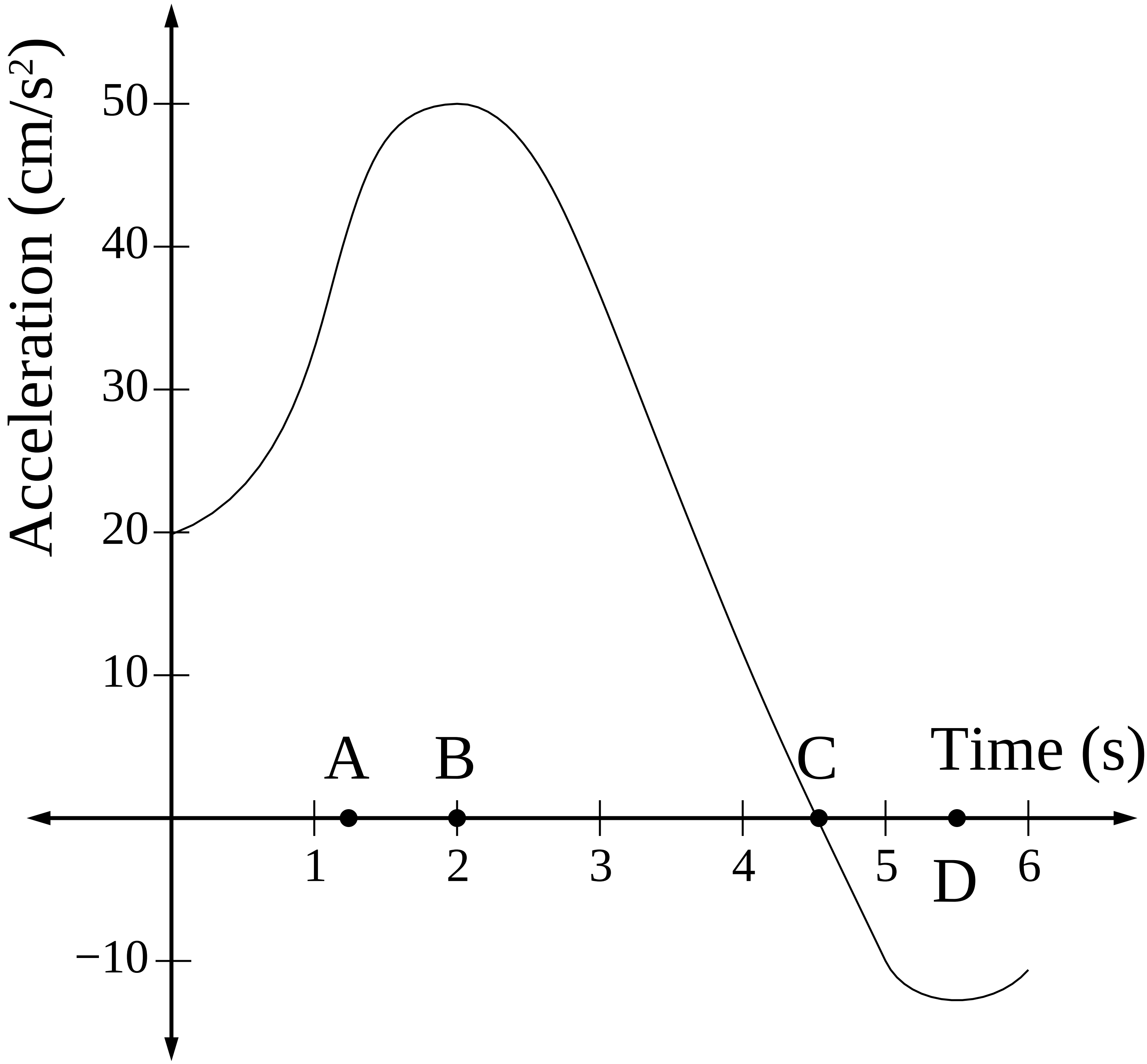

Position (cm)
30
20
10
−10
−20
−30
A
B
C
D
Time (s)
1
2
3
4
5
6



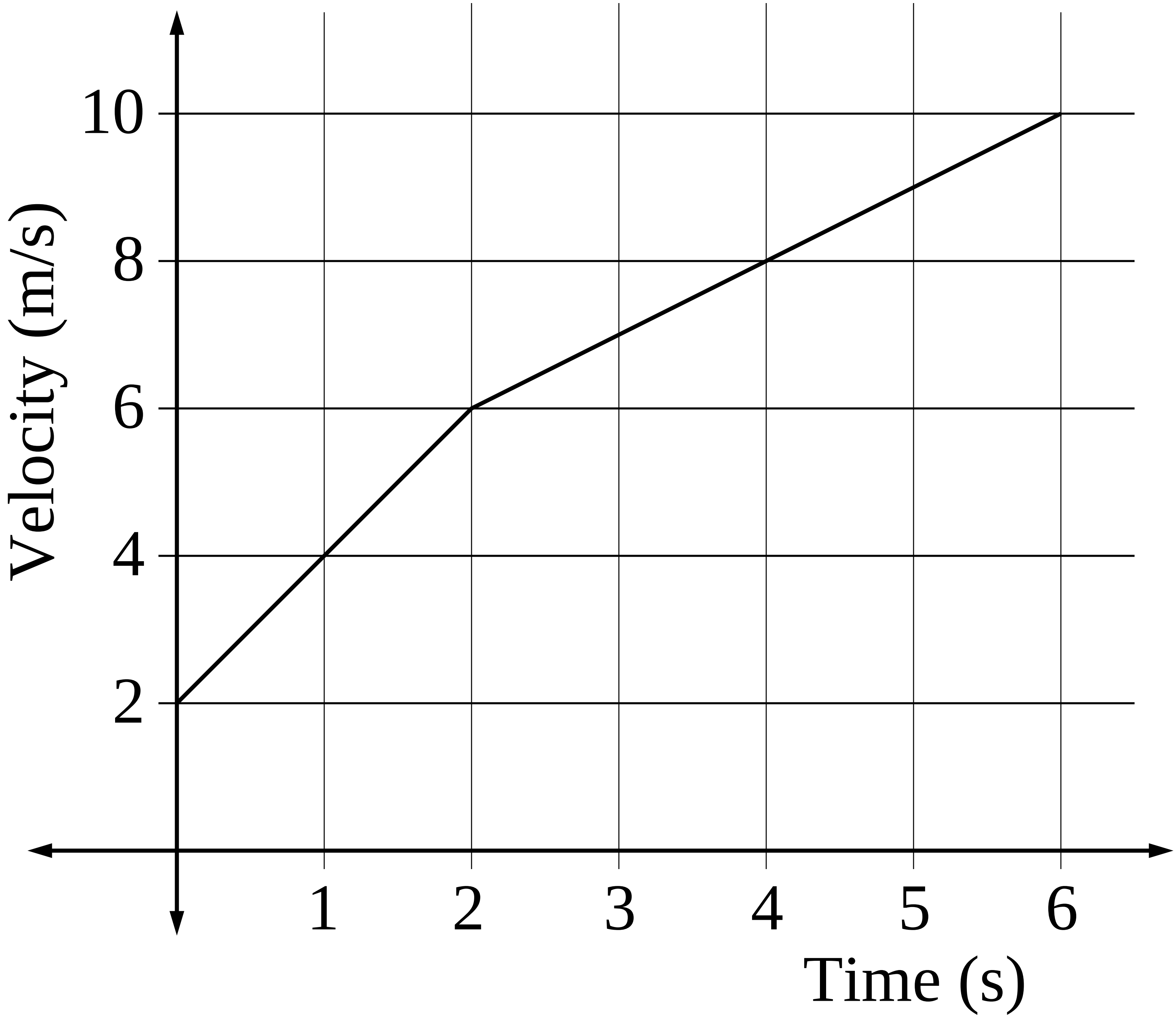
Velocity (cm/s)
30
20
10
−10
−20
A
B
C
D
1
2
3
4
5
6
Time (s)

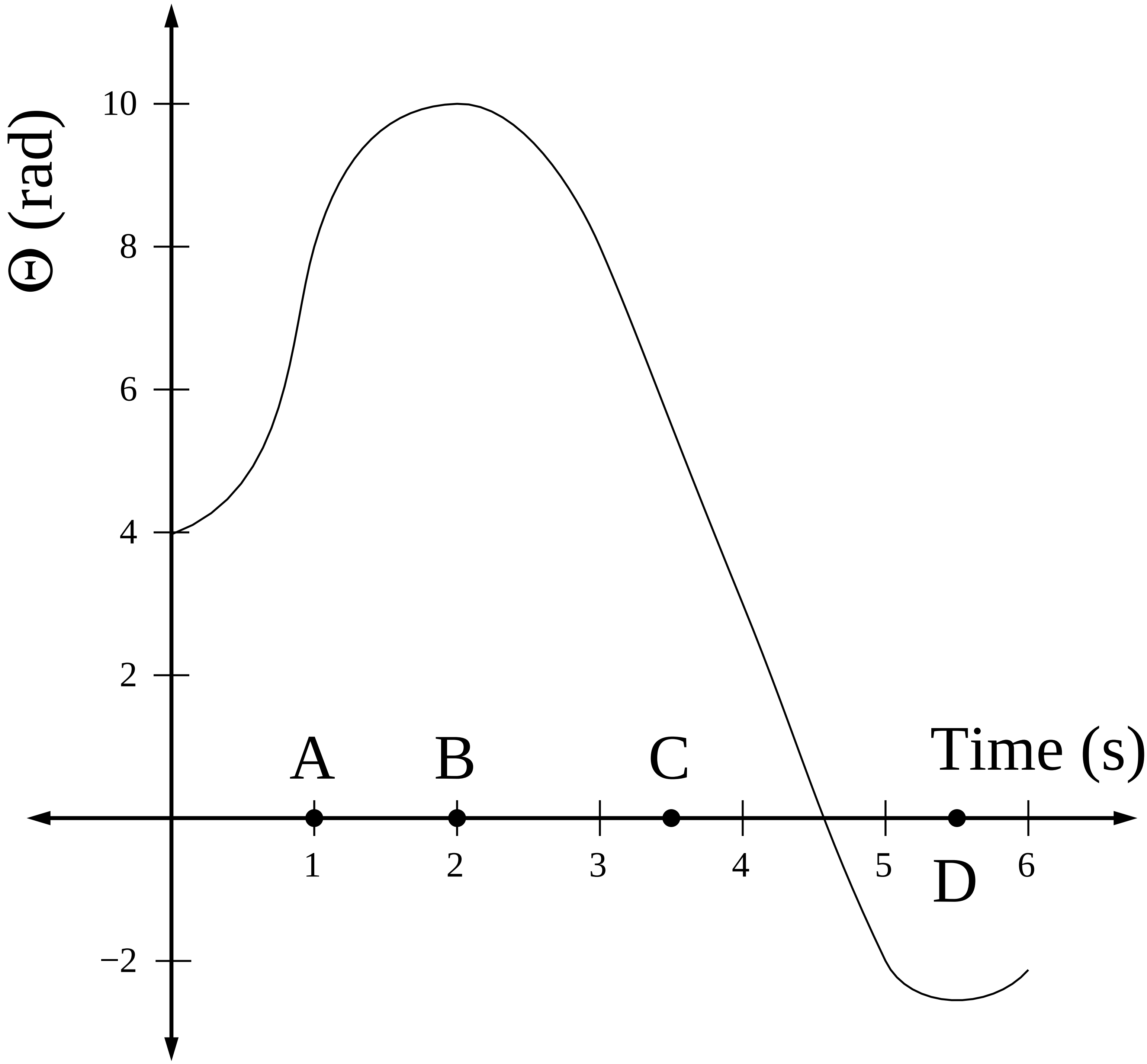

ω (rad/s)
30
20
10
−10
−20
A
B
C
D
1
2
3
4
5
6
Time (s)

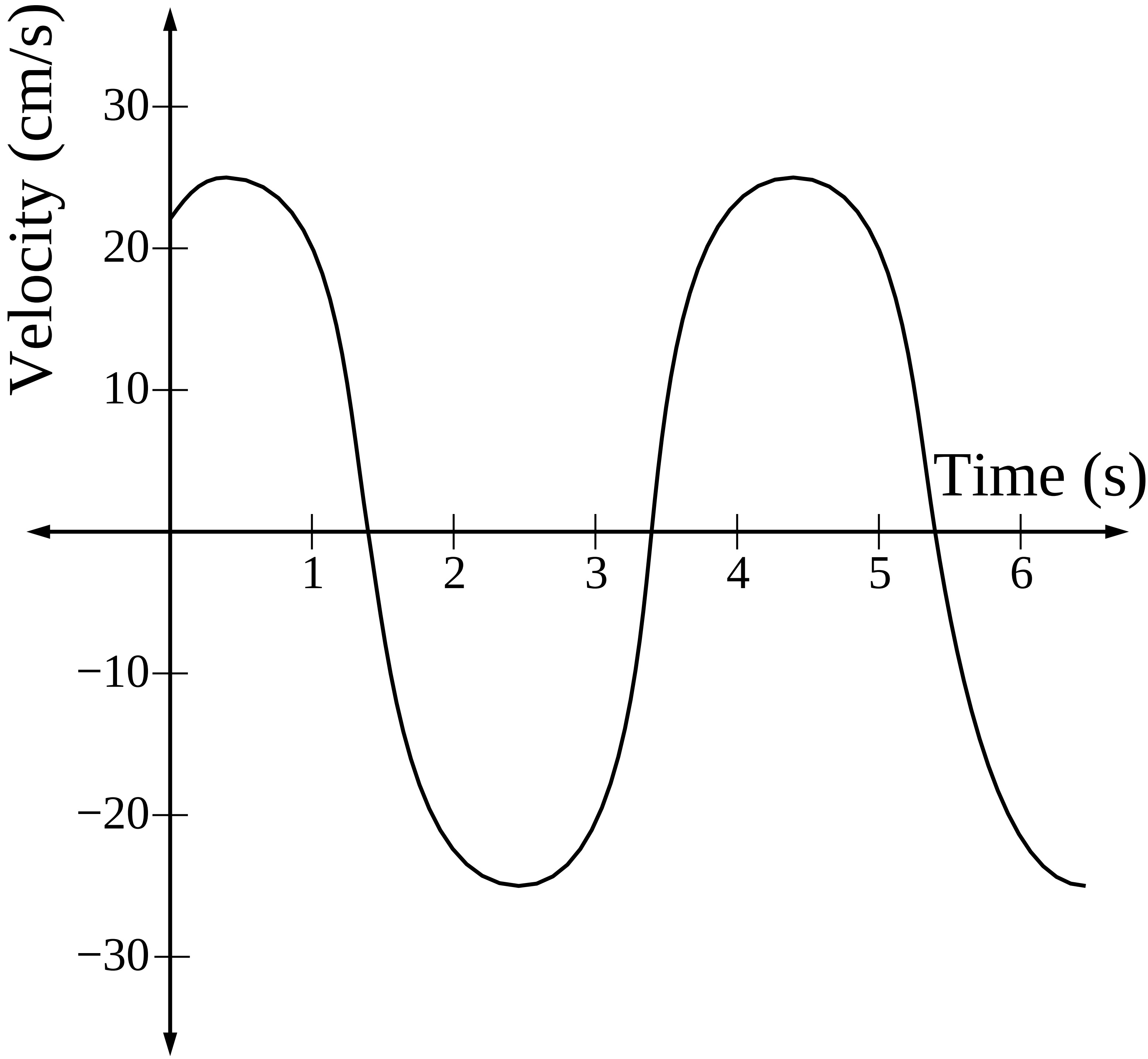

Position (cm)
50
40
30
20
10
−10
A
B
C
D
Time (s)
1
2
3
4
5
6

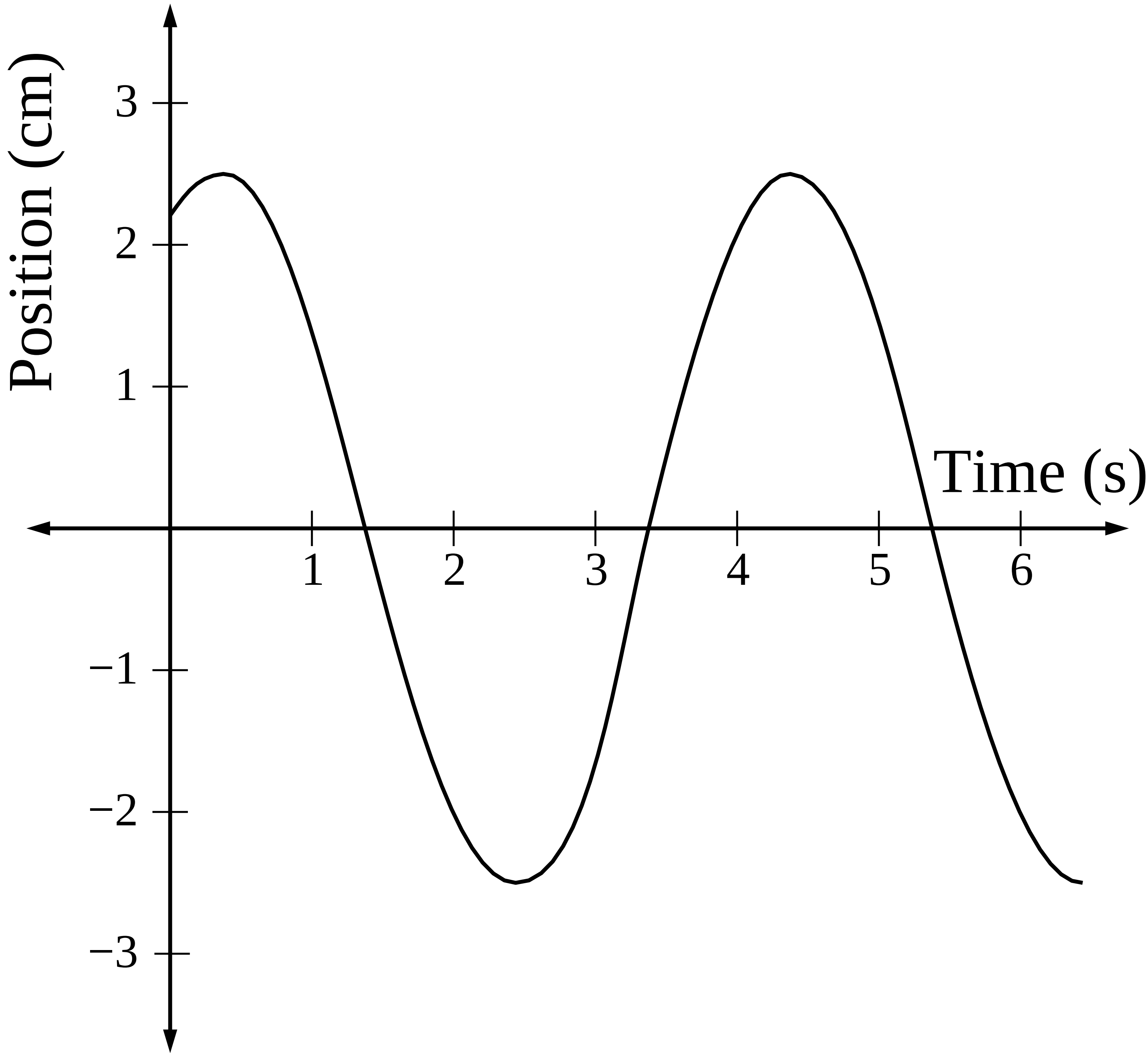


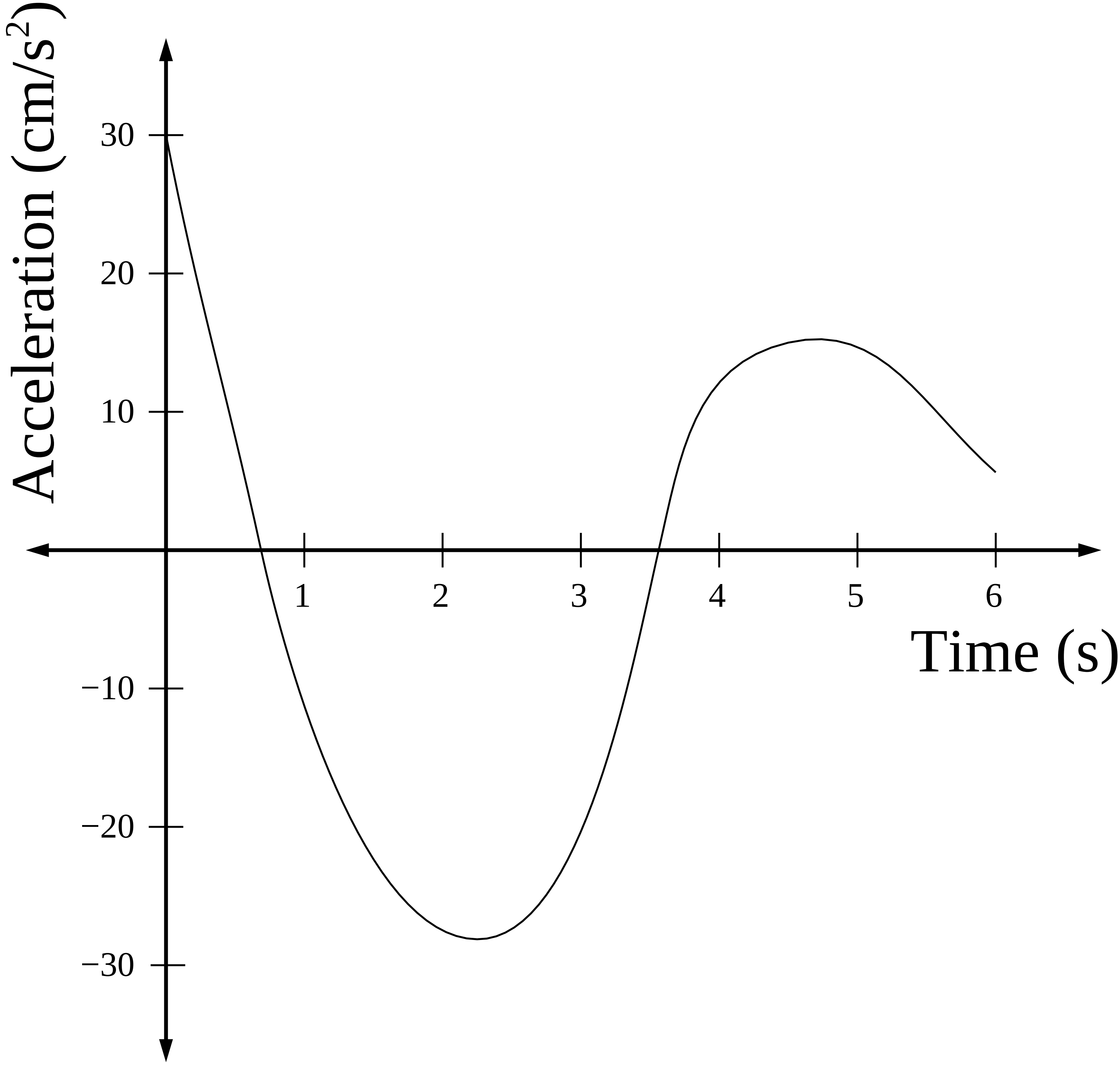
Acceleration (cm/s²)
50
40
30
20
10
−10
A
B
C
Time (s)
1
2
3
4
5
D
6


Velocity (m/s)
10
8
6
4
2
1
2
3
4
5
6
Time (s)

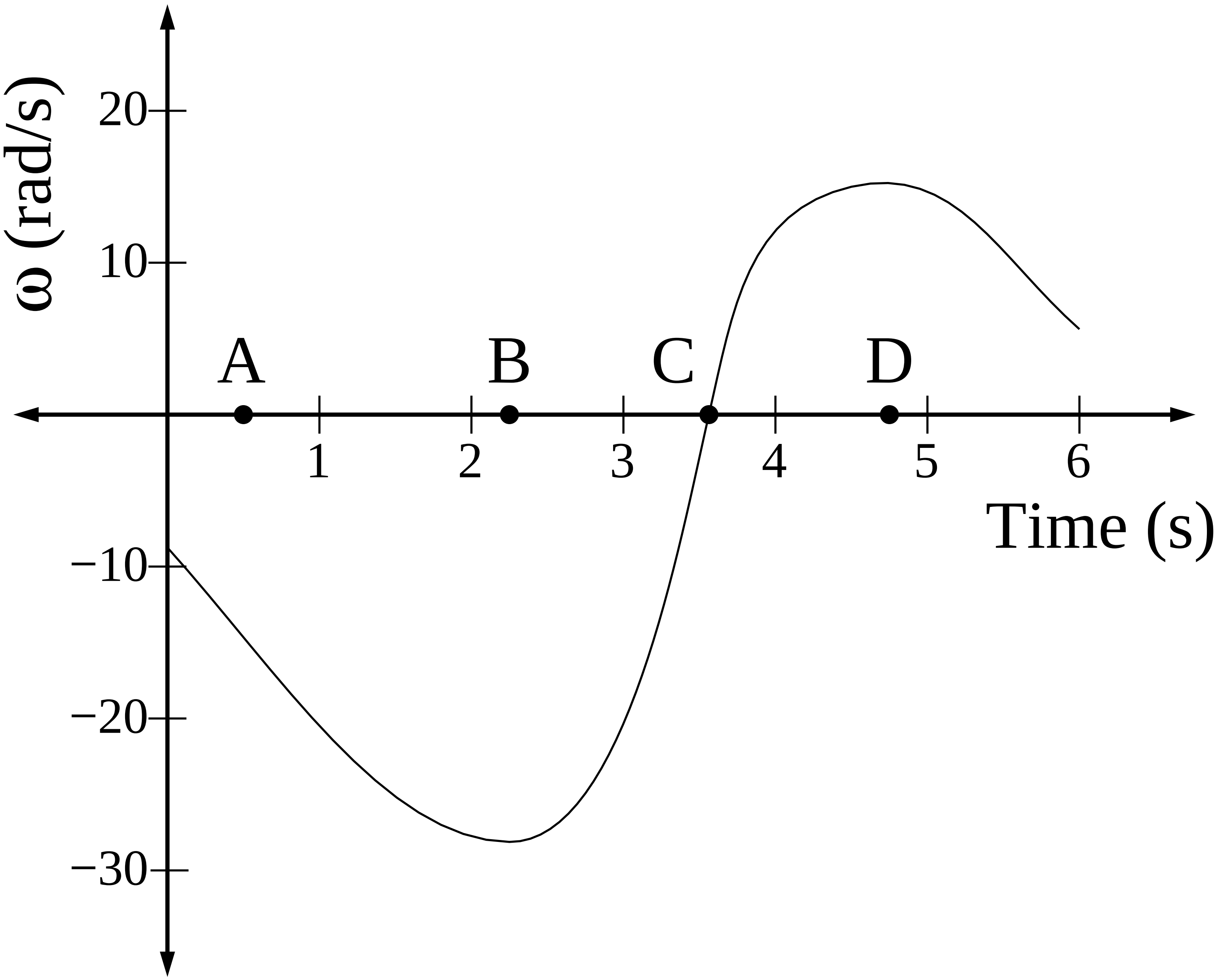

Θ (rad)
10
8
6
4
2
−2
A
B
C
D
Time (s)
1
2
3
4
5
6

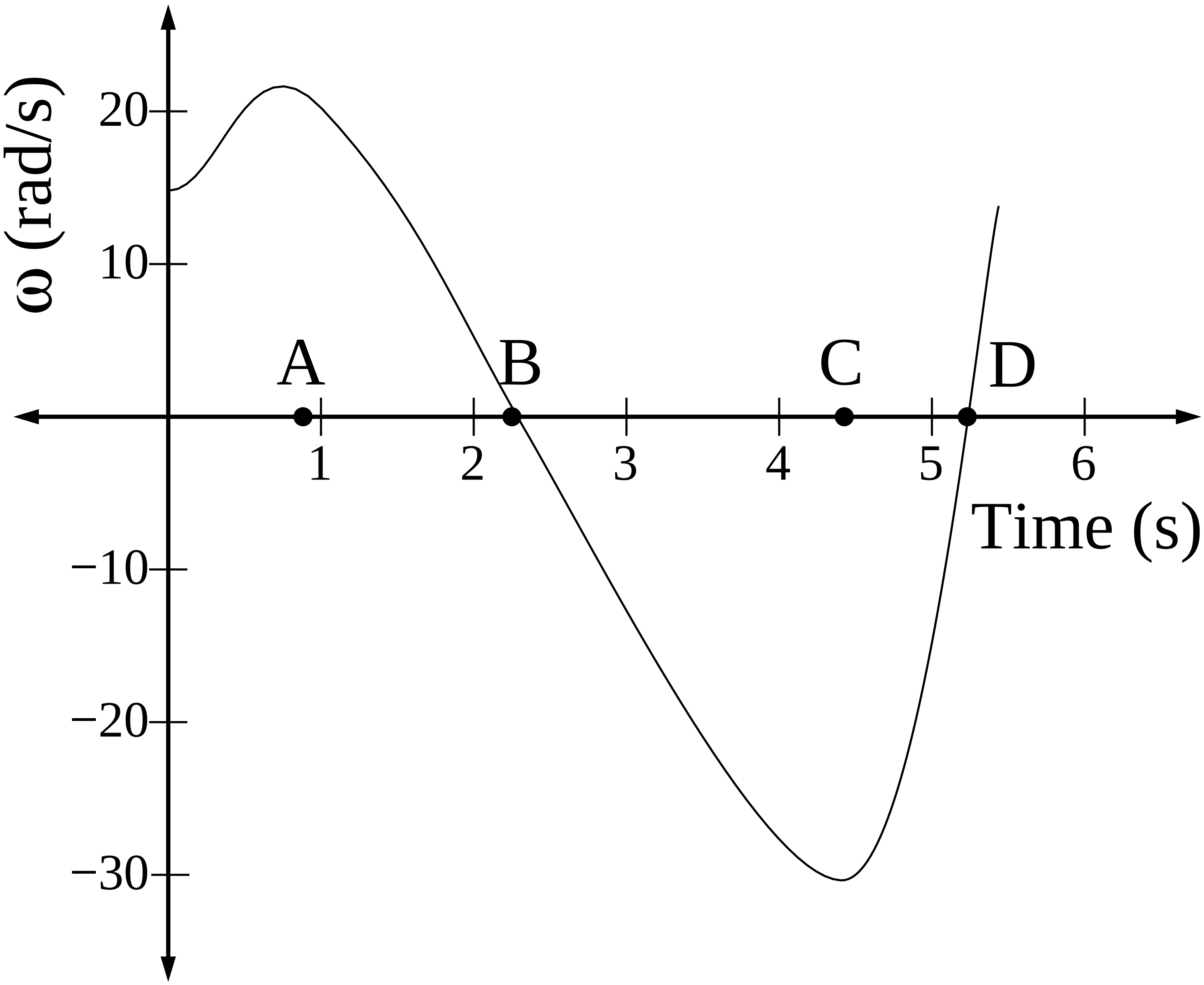

Velocity (cm/s)
30
20
10
−10
−20
−30
Time (s)
1
2
3
4
5
6


Position (cm)
3
2
1
−1
−2
−3
Time (s)
1
2
3
4
5
6

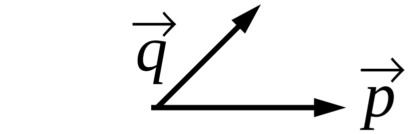


Acceleration (cm/s²)
30
20
10
−10
−20
−30
1
2
3
4
5
6
Time (s)

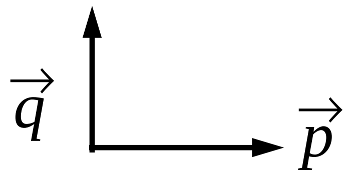

ω (rad/s)
20
10
−10
−20
−30
A
B
C
D
1
2
3
4
5
6
Time (s)


ω (rad/s)
20
10
−10
−20
−30
A
B
C
D
1
2
3
4
5
6
Time (s)

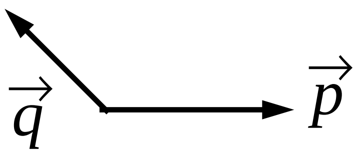
A



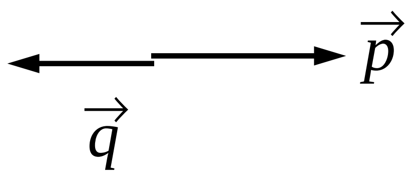
B



C



D

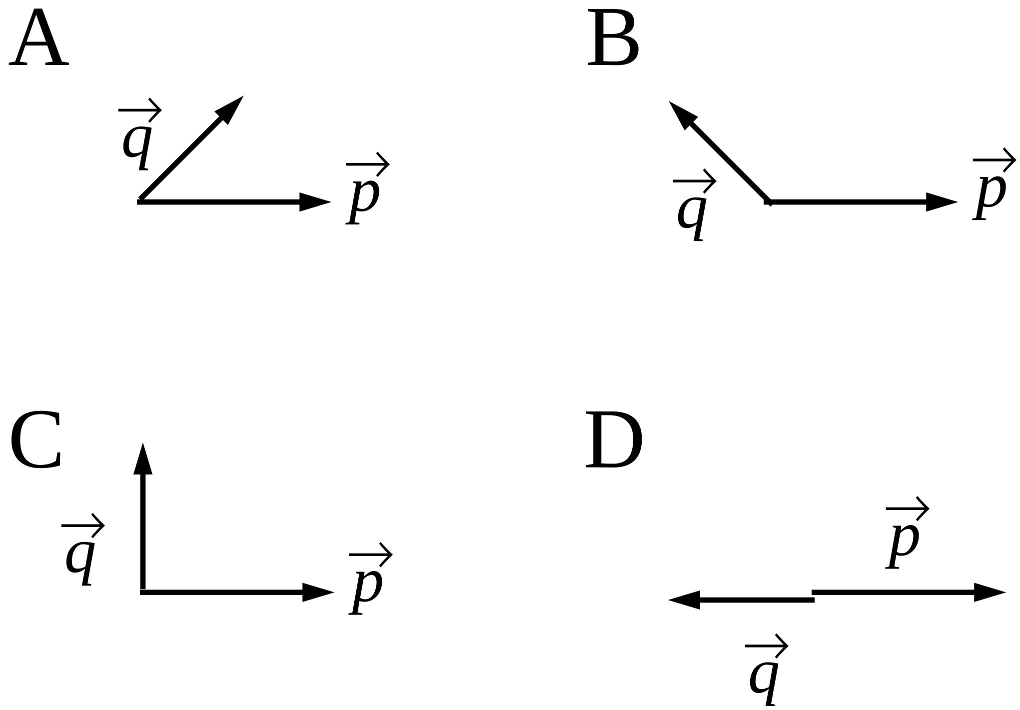


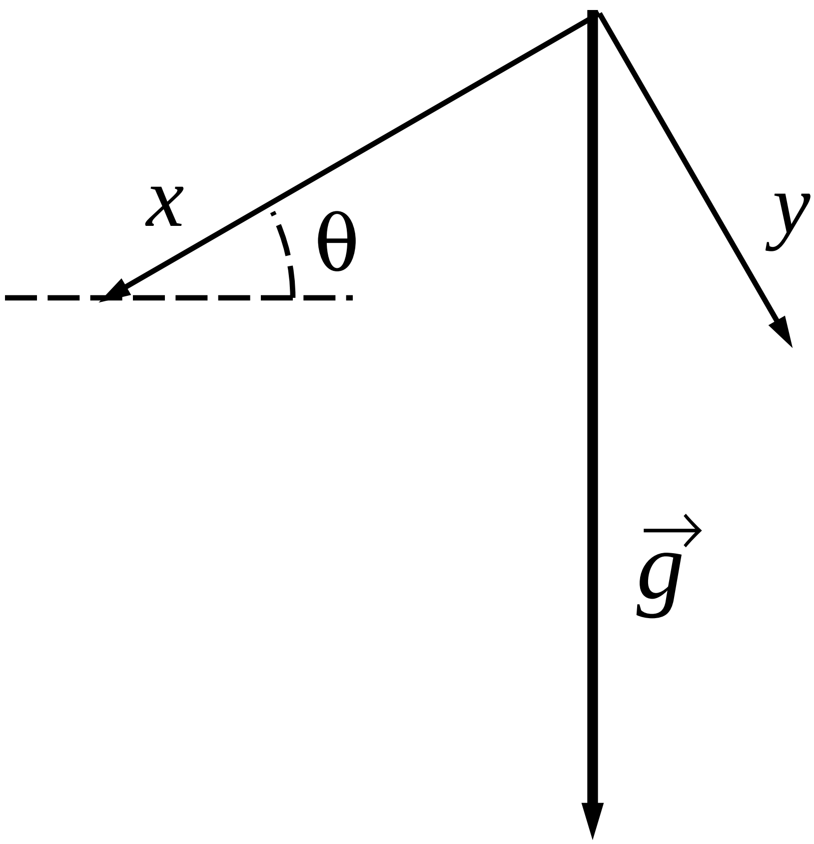
$\vec{p} + \vec{q}$ 1

$\vec{p} - \vec{q}$ 2

$\vec{p} \times \vec{q}$ 3

$\vec{p} \bullet \vec{q}$ 4


A
B
C
D
$\vec{q}$
$\vec{p}$

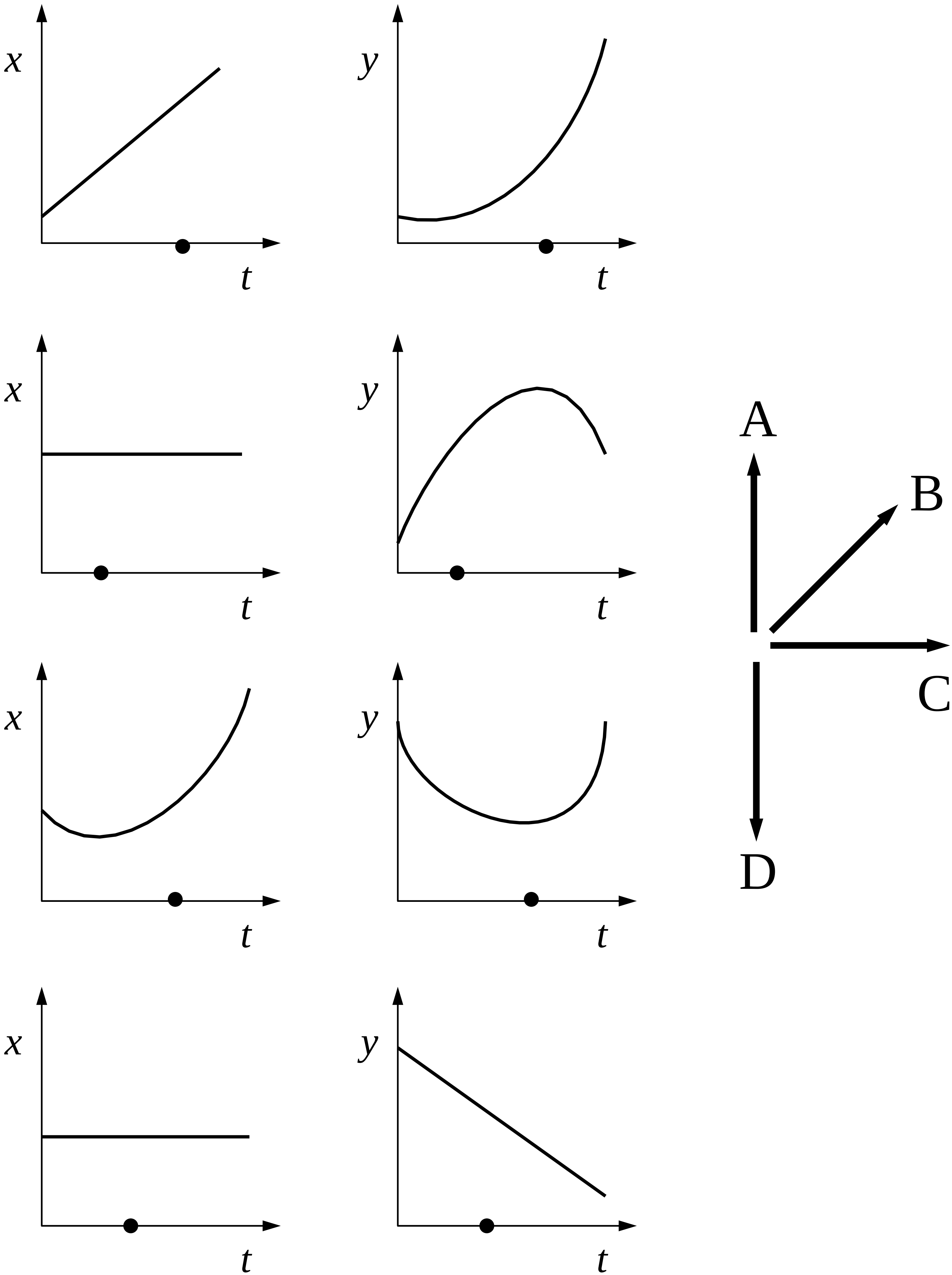


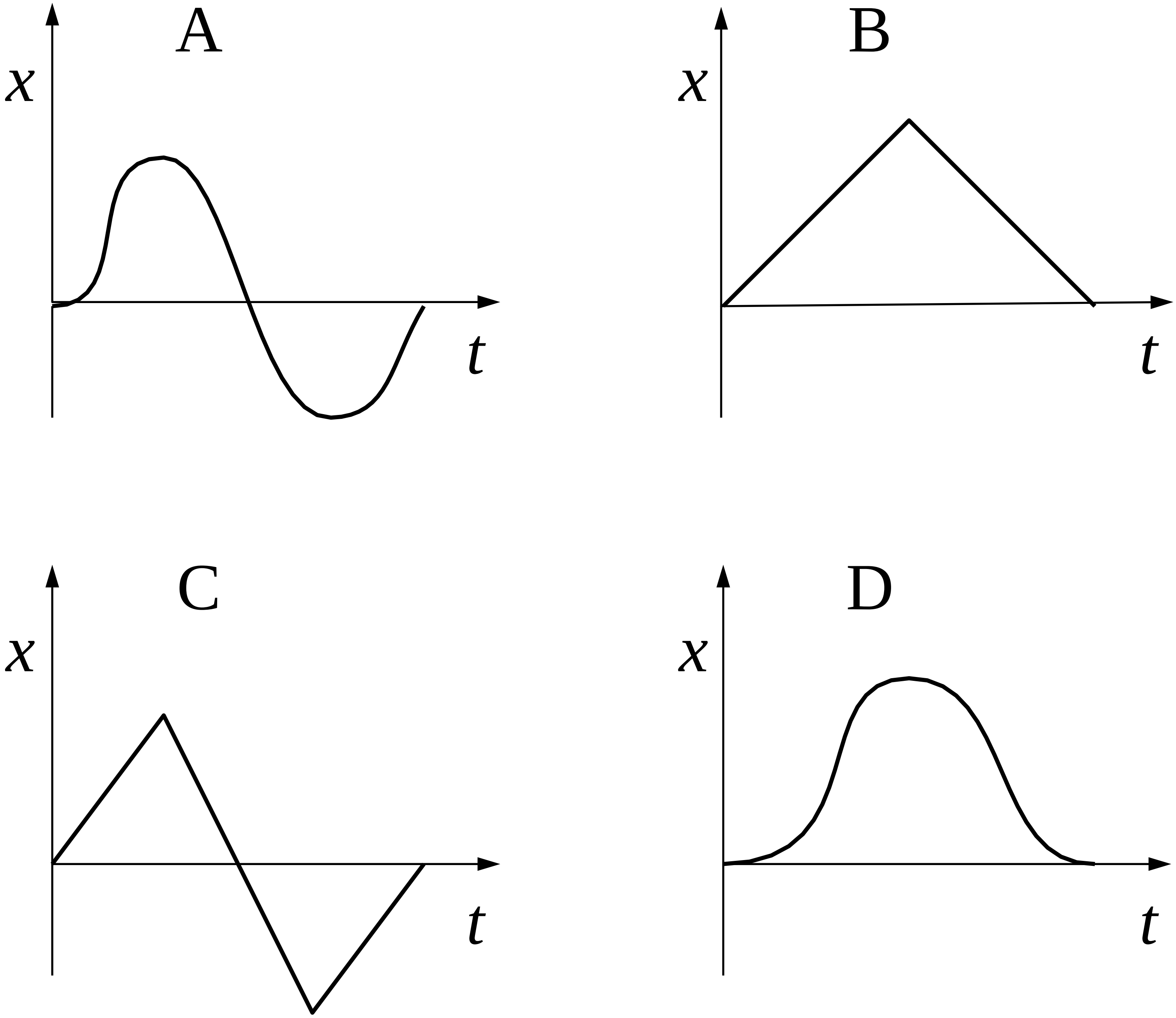
A $g_x = |\vec{\boldsymbol{g}}| \cos\theta$

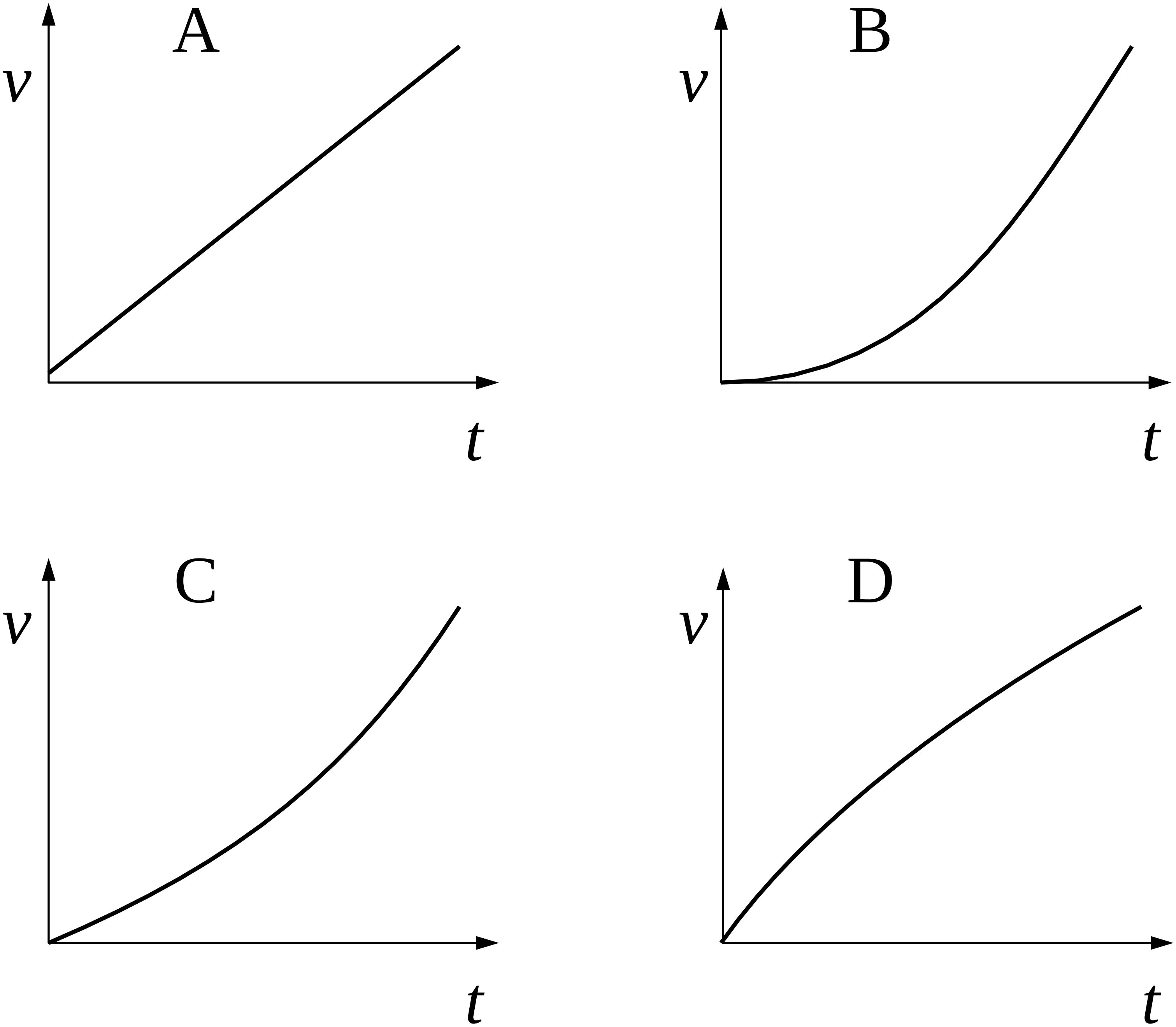
B $g_x = |\vec{\boldsymbol{g}}| \sin\theta$

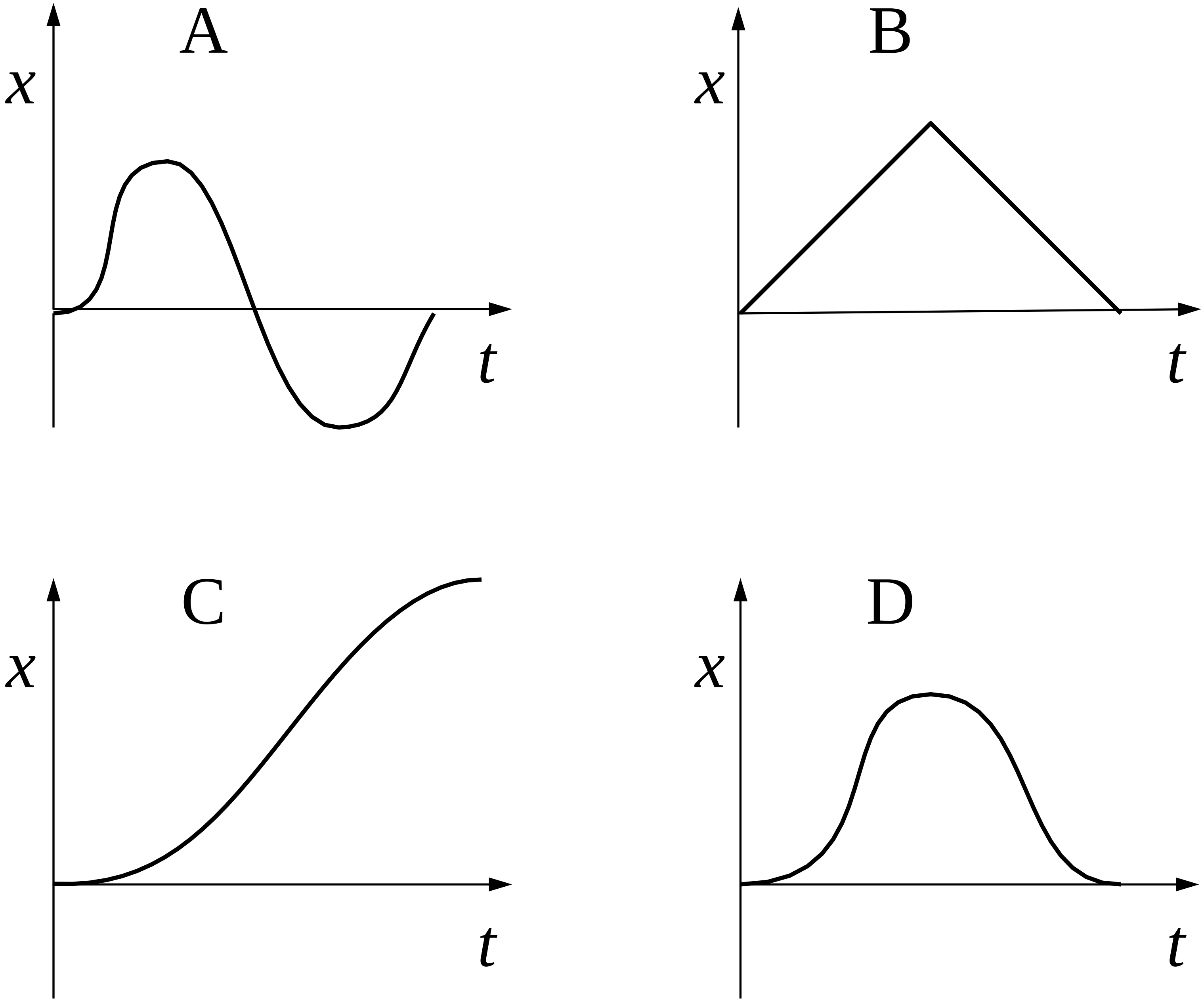
C $g_x = |\vec{\boldsymbol{g}}| \sin(90^\circ - \theta)$

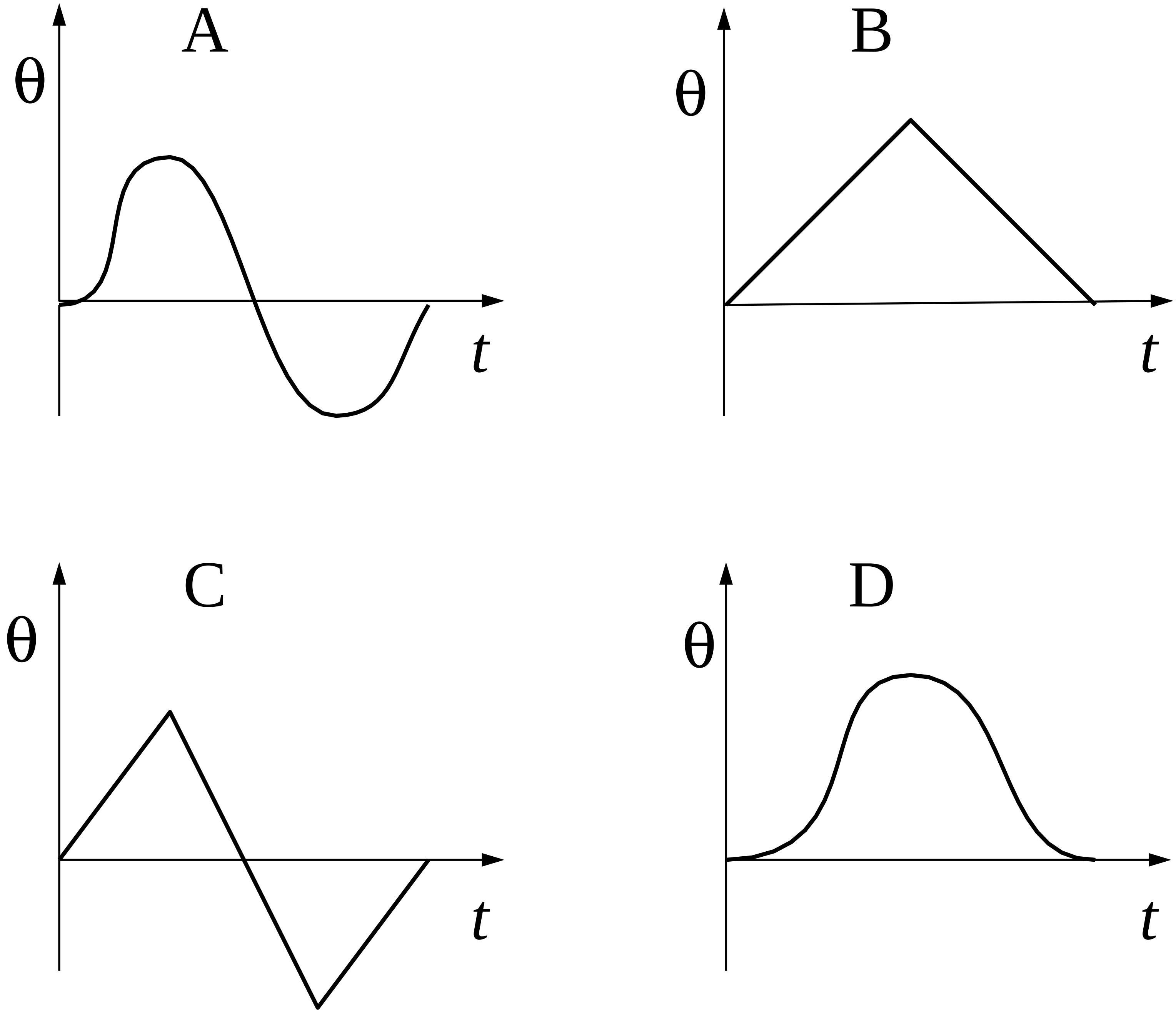
D $g_x = |\vec{\boldsymbol{g}}| \cos(180^\circ - \theta)$

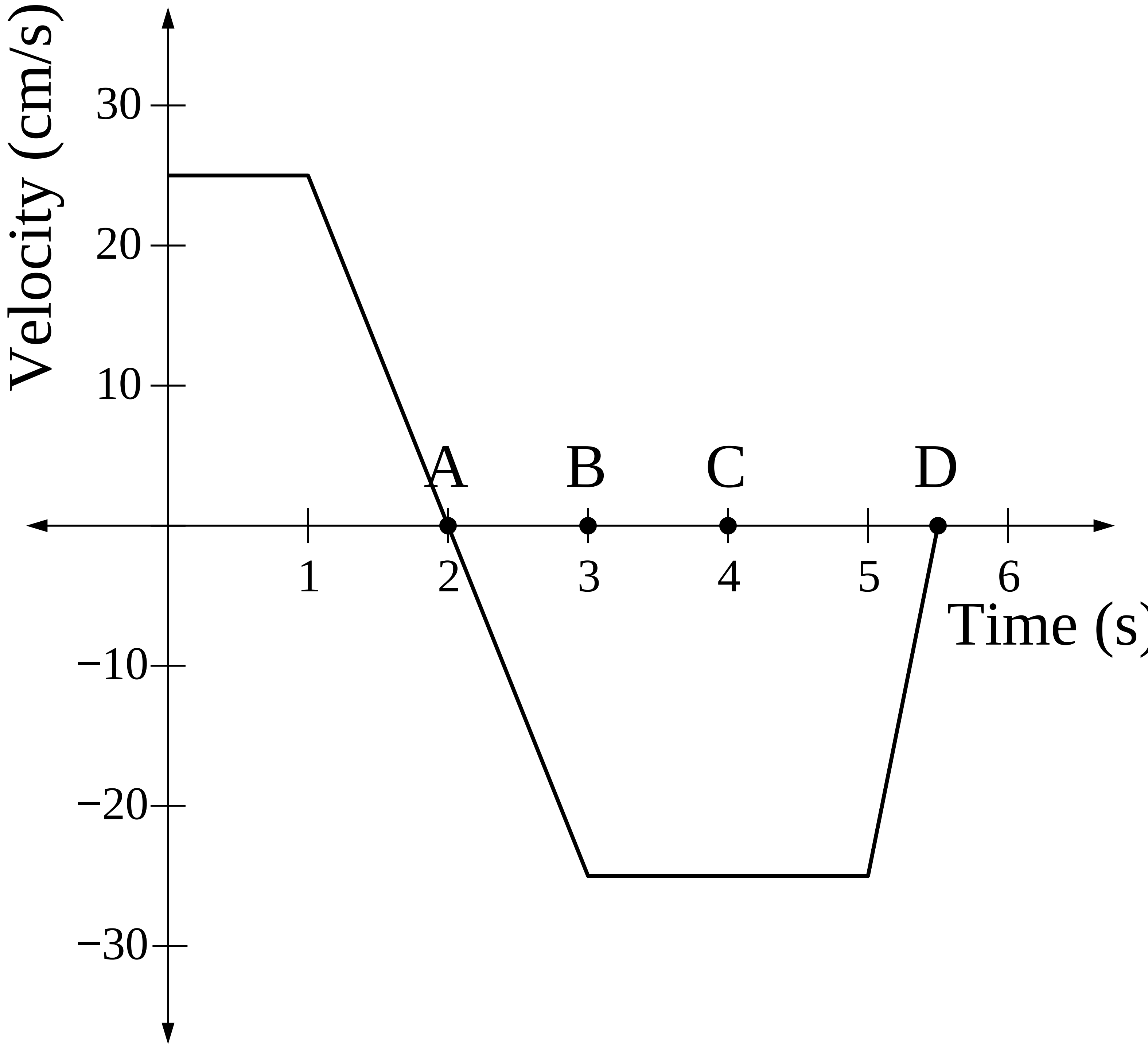

x
y
t
x
y
t
x
y
t
x
y
t
A
B
C
D


A
x
t
B
x
t
C
x
t
D
x
t


A
v
t
B
v
t
C
v
t
D
v
t

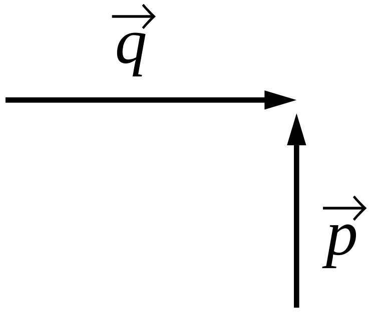

A
x
t
B
x
t
C
x
t
D
x
t


A
θ
t
B
θ
t
C
θ
t
D
θ
t

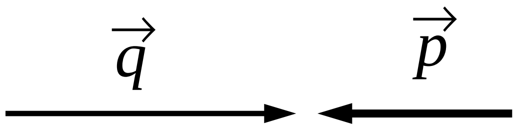


Velocity (cm/s)
30
20
10
−10
−20
−30
A
B
C
D
1
2
3
4
5
6
Time (s)

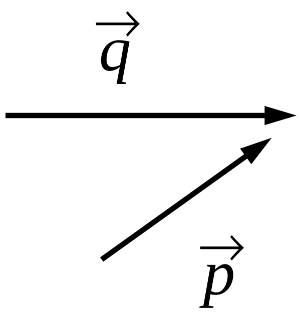
A



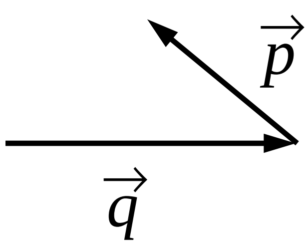
B

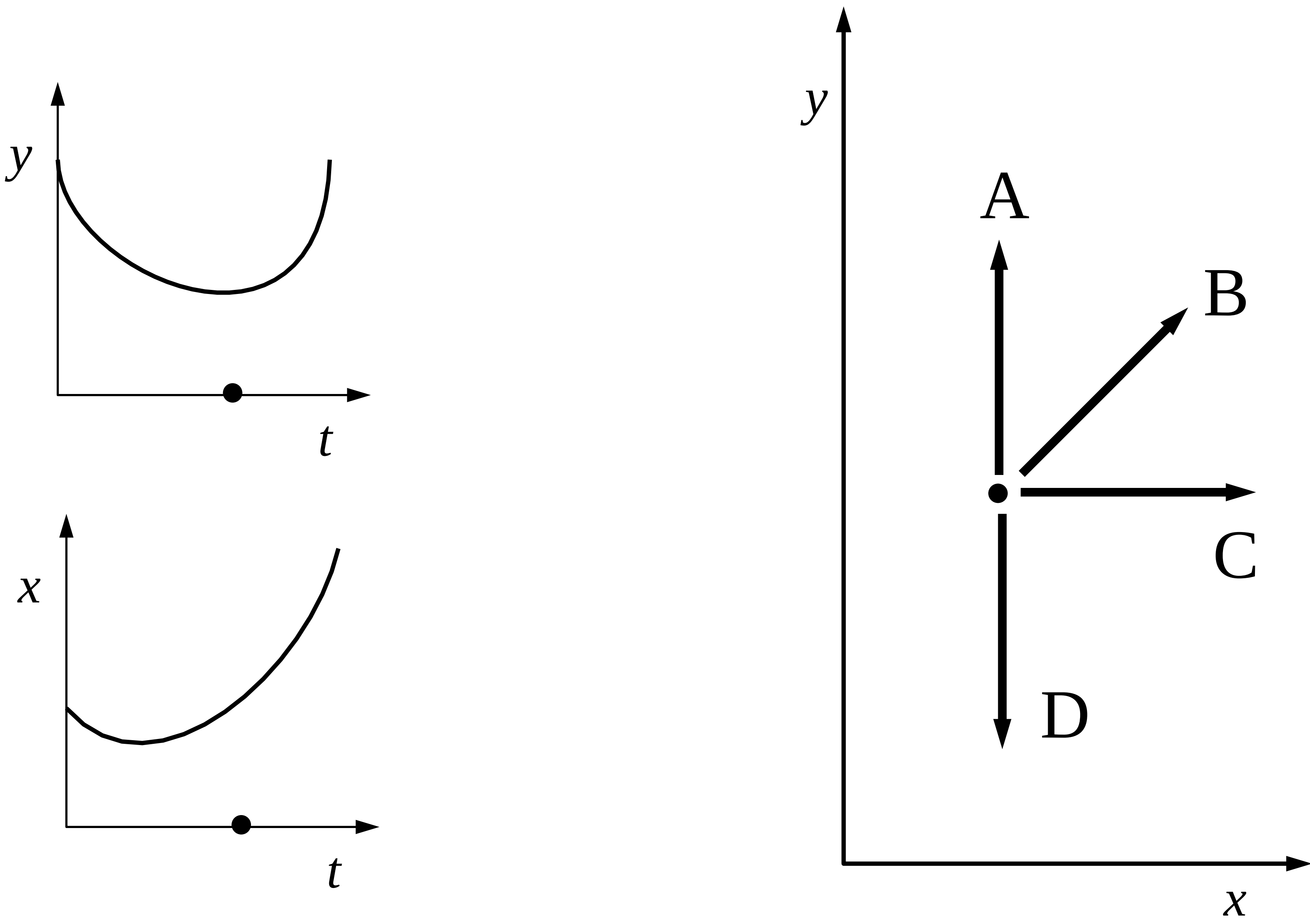


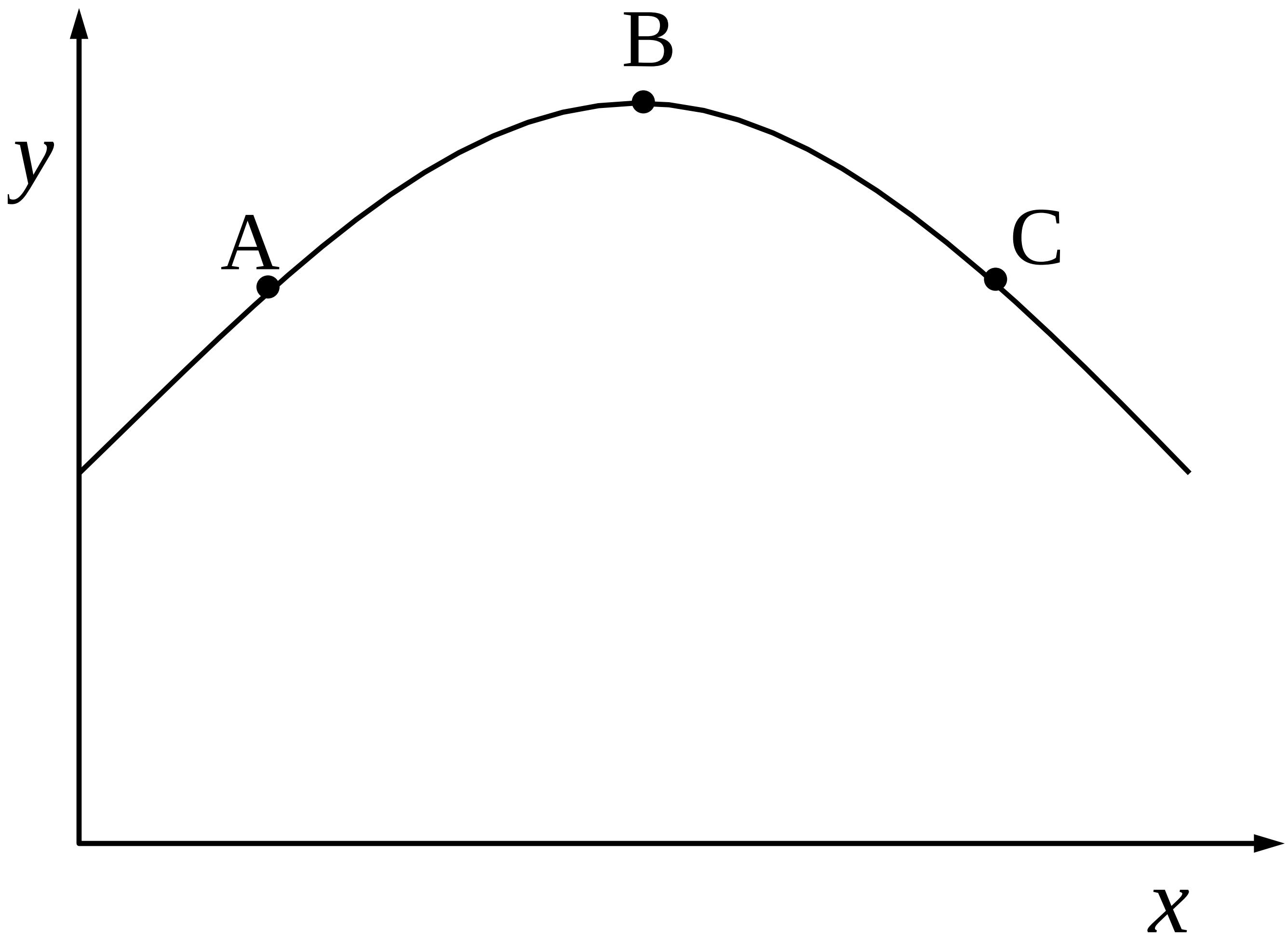
C



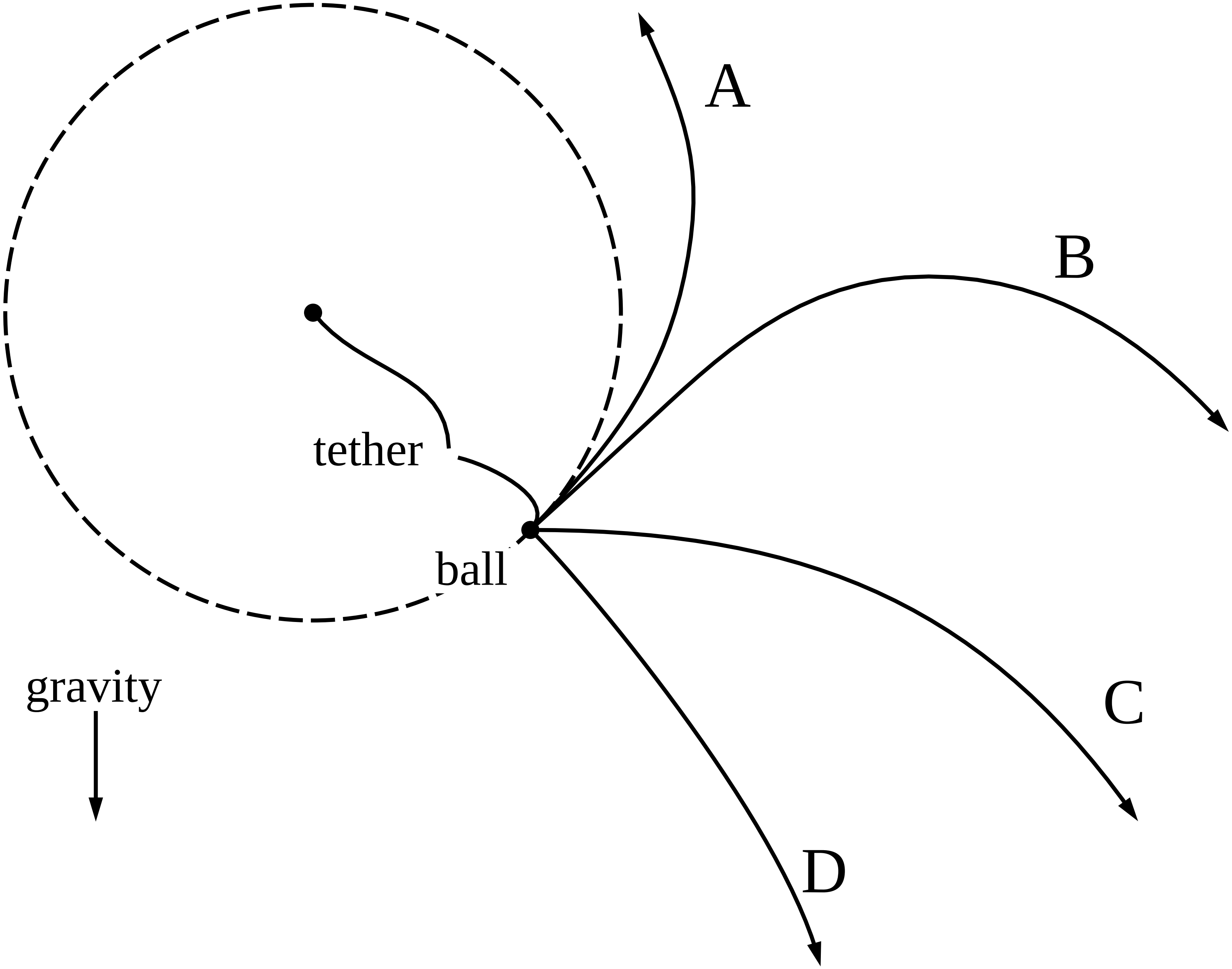
D




y
t
x
t
y
A
B
C
D
x

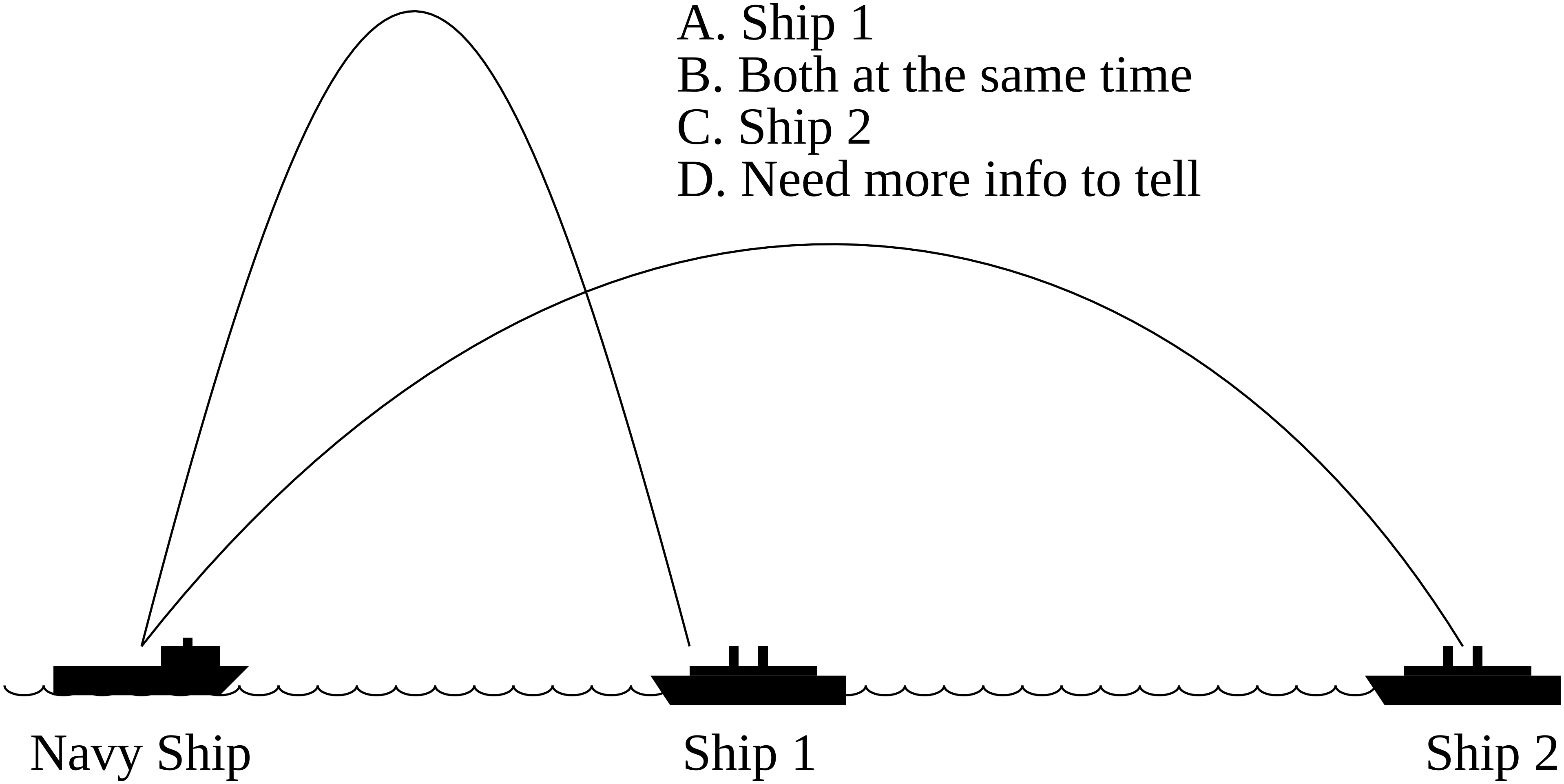


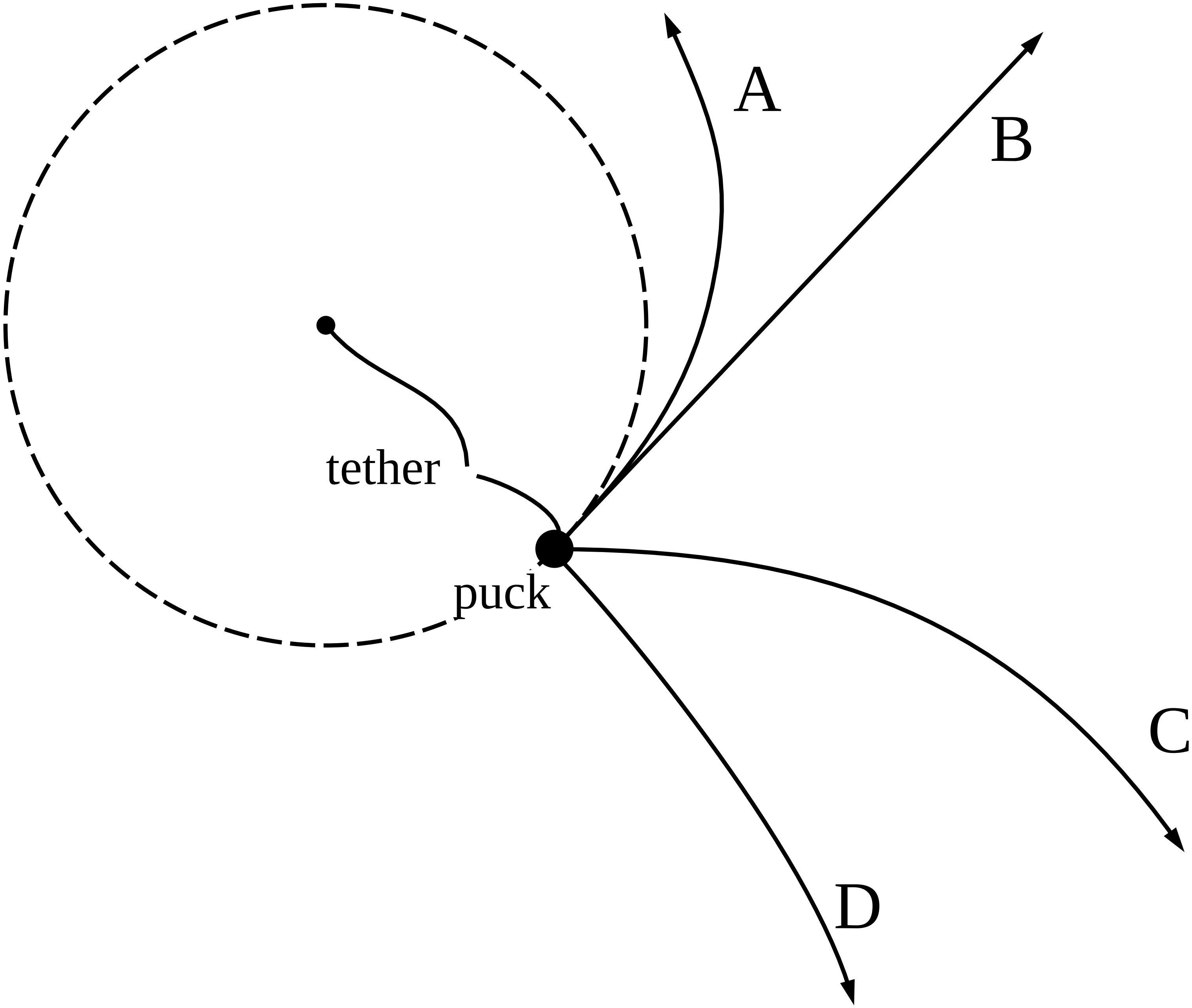
D: none of the above

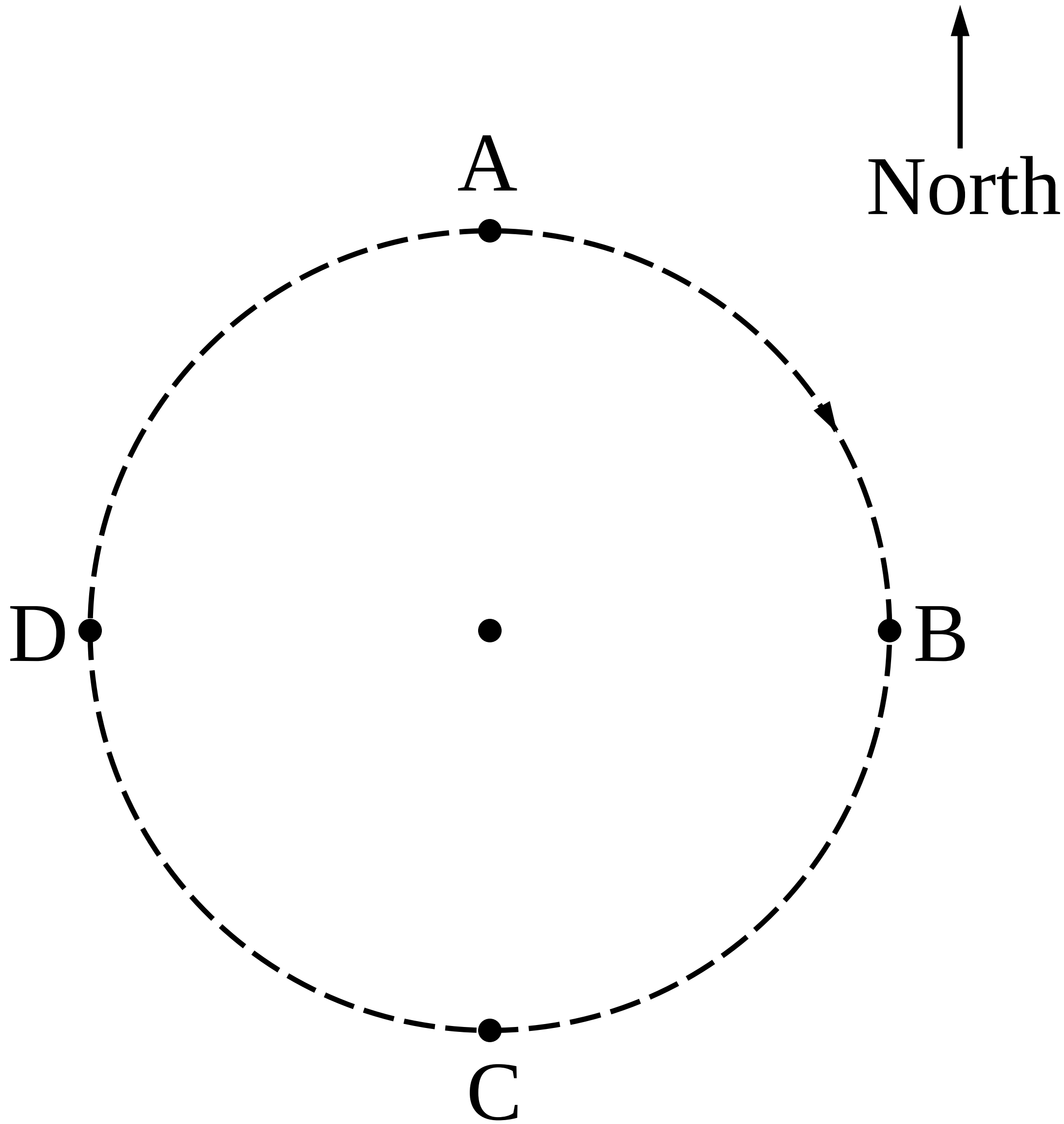

A
B
tether
ball
C
gravity
D

A navy ship simultaneously fires shells at two enemy ships. The shells follow the parabolic trajectories shown in the diagram below. (Assume zero air resistance.) Which of the two enemy ships gets hit first?

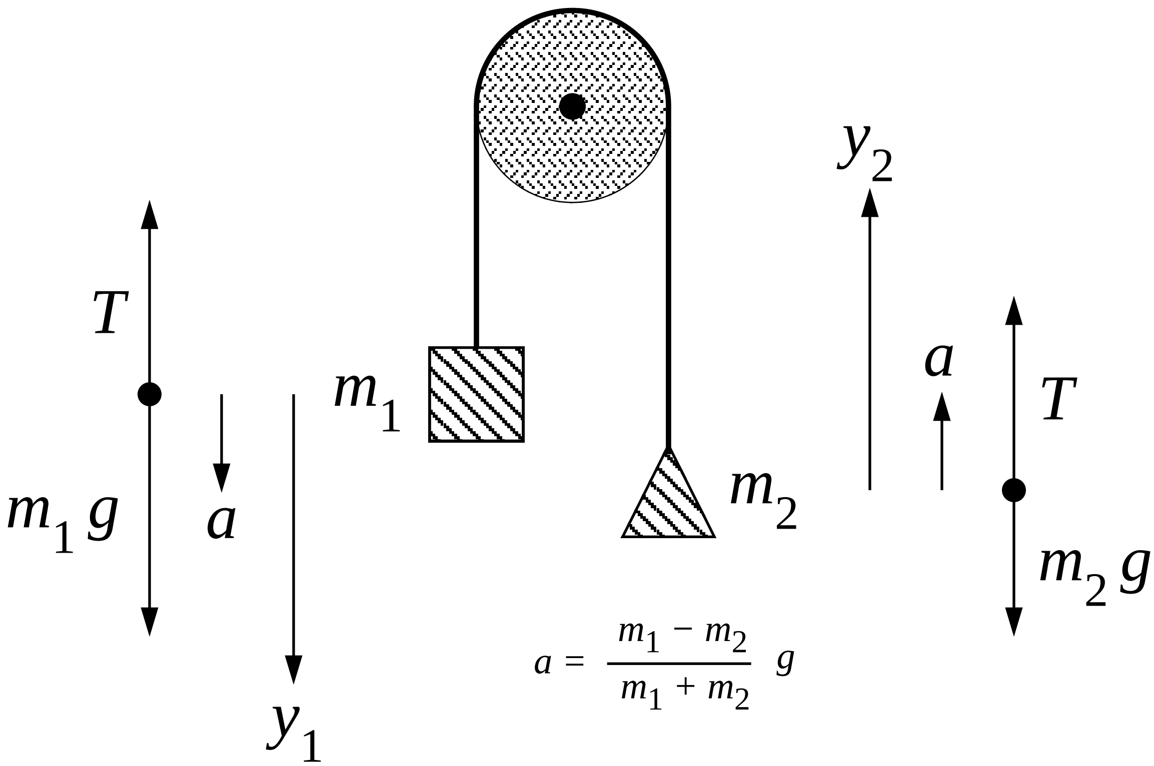
A. Ship 1
B. Both at the same time
C. Ship 2
D. Need more info to tell




A
B
tether
puck
C
D



A
North
D
B
C



$$a = \frac{m_1 - m_2}{m_1 + m_2}\, g$$

T : string tension with units of force
m : various masses
g : 9.8 m/s^2
θ : angle with allowed range: [0°, 90°]
r : radius
I : Moment of Inertia units: ML^2

A. unit problem
B. infinite acceleration for realizable parameters
C. zero acceleration possible
D. none of the above

1 $$a = \frac{m_1 - m_2}{m_1 + m_2} g$$

6 $$a = \frac{m_1 - m_2 \sin(\theta)}{m_1 + m_2} g$$

2 $$a = \frac{T + g}{m}$$

7 $$a = \frac{g}{\tan(\theta)}$$

3 $$a = g \tan(m_1 - m_2)$$

8 $$a = g \tan(mg/T)$$

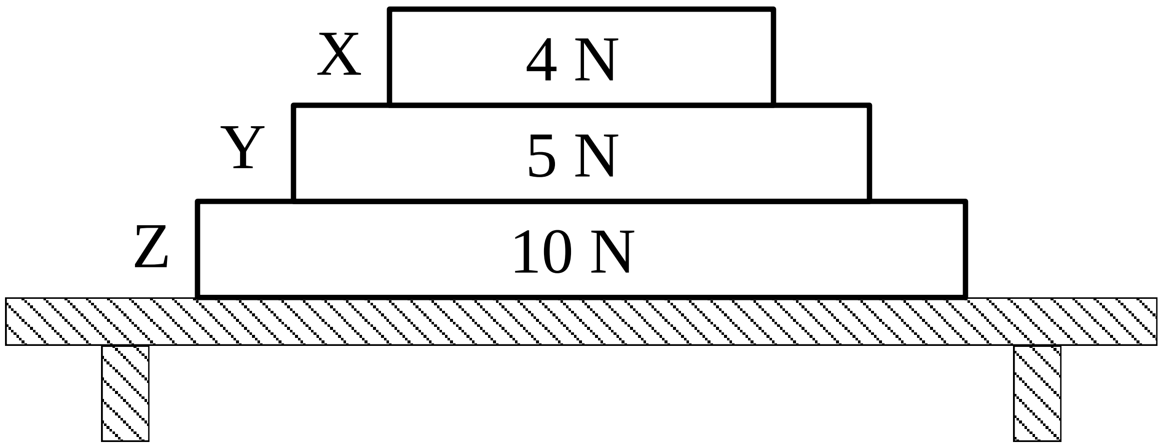
4 $$a = \frac{mg \sin(\theta)}{I/r^2 + m}$$

9 $$a = \frac{1}{m/T + 1/g}$$

5 $$a = \frac{mg}{\sin(\theta) + m}$$

10 $$a = \sqrt{Tg/m}$$

Three books (X, Y, and Z) rest on a table. The weight (i.e., *mg*) of each book is indicated.



1) The net force acting on the book Y is:

A. 4 N down
B. 9 N down
C. zero
D. 5 N up

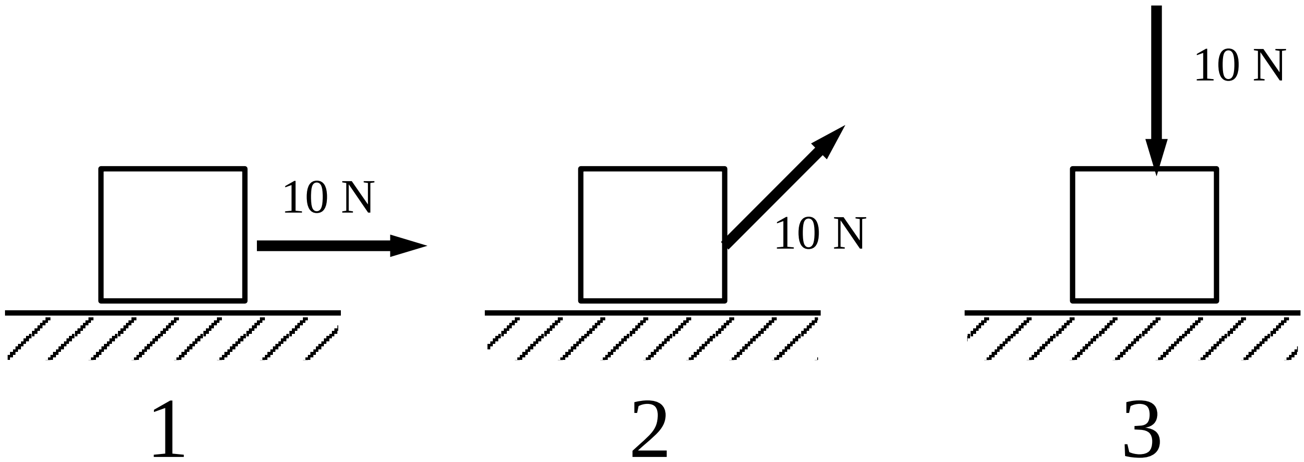
2) The force of book Z on book Y is:

A. 5 N up
B. 9 N up
C. 19 N up
D. zero

3) The force of book Y on the table is:

A. 5 N up
B. 5 N down
C. 19 N down
D. zero

A crate rests on a horizontal surface and a man pulls on it with a 10 N force. No matter what the orientation of the force, the crate does not move. Below are displayed three attempts to move the crate.



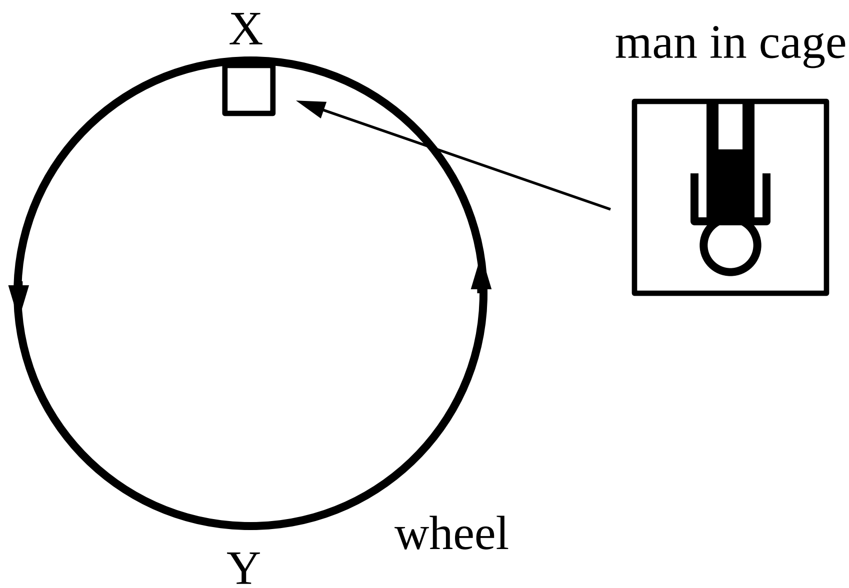
1) Rank the situations shown above according to the magnitude of the frictional force exerted by the surface on the crate, least to greatest.

A. 1 < 2 < 3
B. 3 < 2 < 1
C. 2 < 1 < 3
D. 3 < 1 < 2

2) Rank the situations shown above according to the magnitude of the normal force exerted by the surface on the crate, least to greatest.

A. 1 < 2 < 3
B. 3 < 2 < 1
C. 2 < 1 < 3
D. 3 < 1 < 2

A giant wheel having a diameter of 40 m, is fitted with a cage and platform on which a man of mass *m* stands. The wheel is rotated at constant speed in a vertical plane at such a speed that the force exerted by the man on the platform is equal to his weight when the cage is at X, as shown. The net force on the man at the point X is:

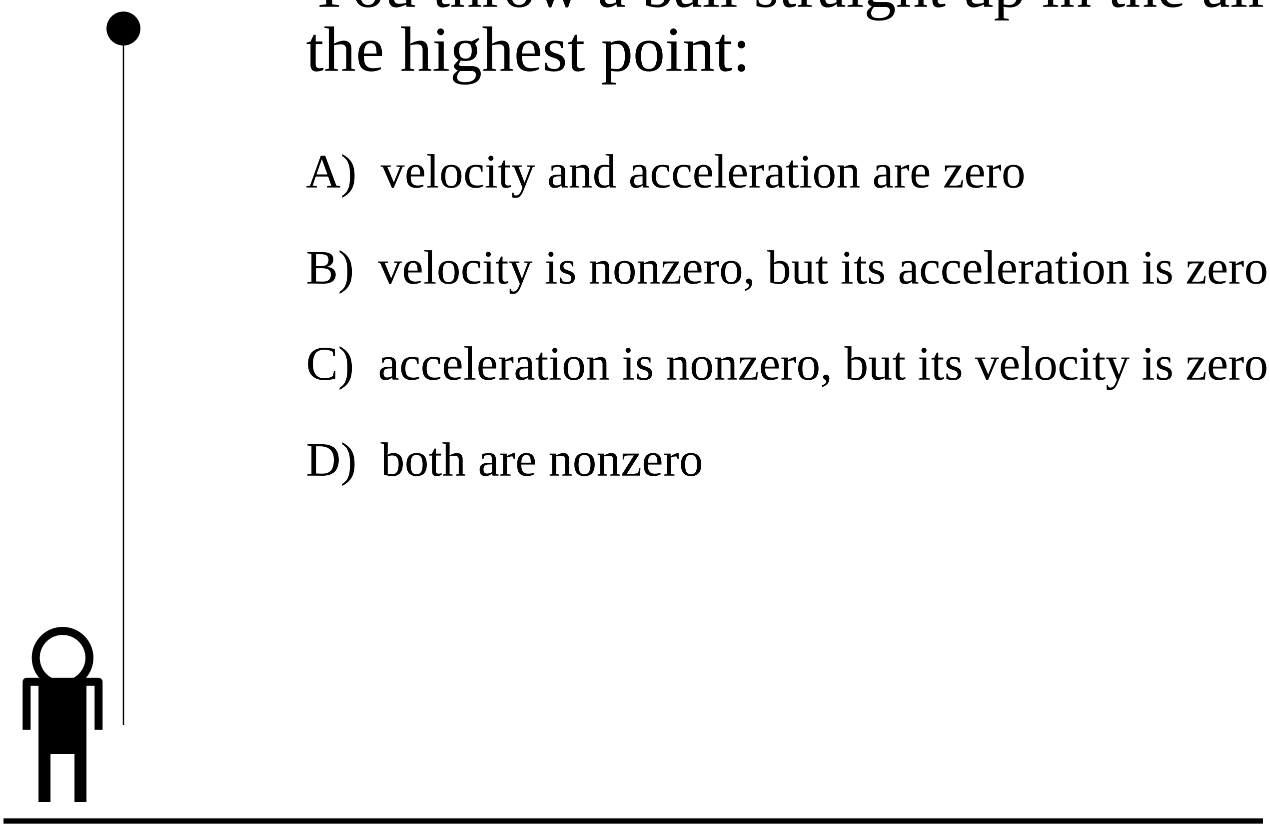


A. zero
B. *mg*, down
C. *mg*, up
D. 2*mg*, down

The net force on the man at point Y (the bottom of the wheel) is:

A. zero
B. *mg*, up
C. 2*mg*, up
D. 2*mg*, down

You throw a ball straight up in the air. At the highest point:



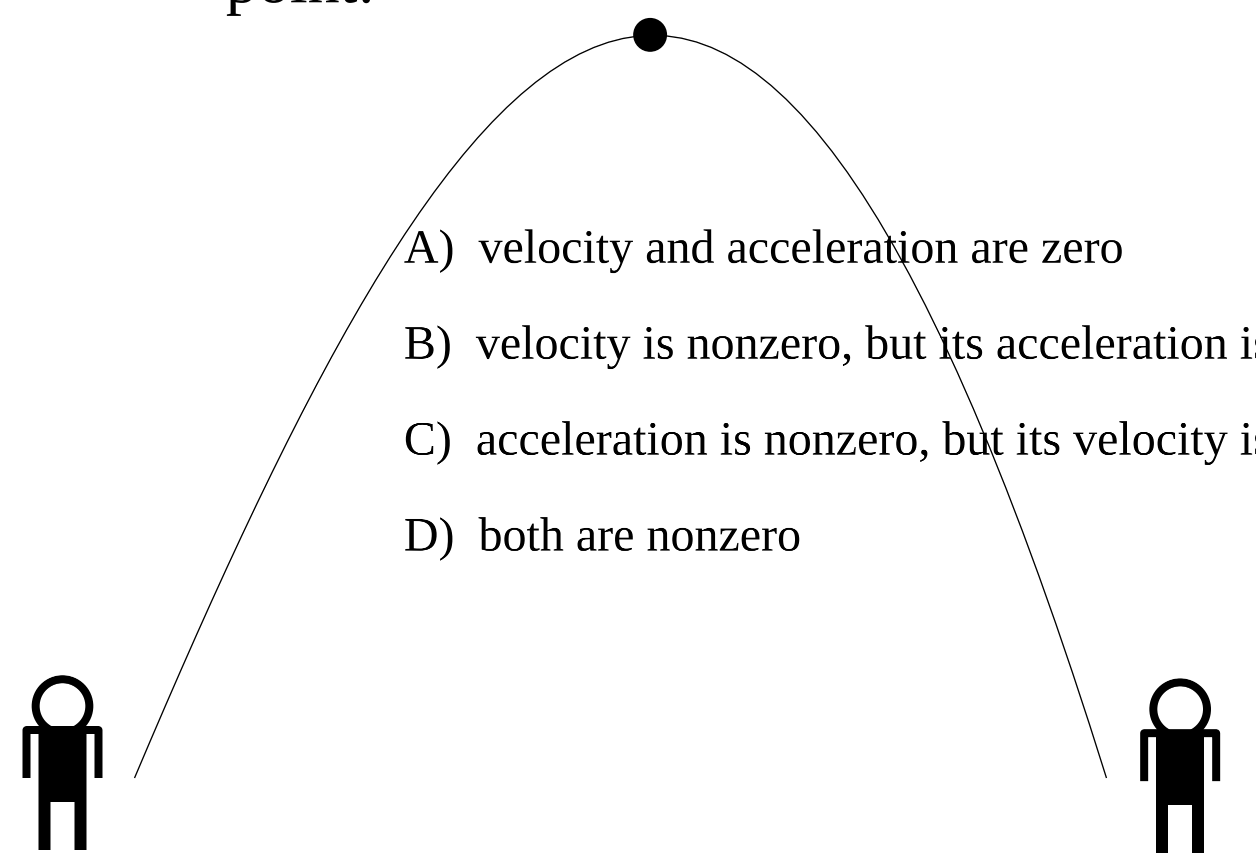
A) velocity and acceleration are zero

B) velocity is nonzero, but its acceleration is zero

C) acceleration is nonzero, but its velocity is zero

D) both are nonzero

You throw a ball to a friend. At the highest point:

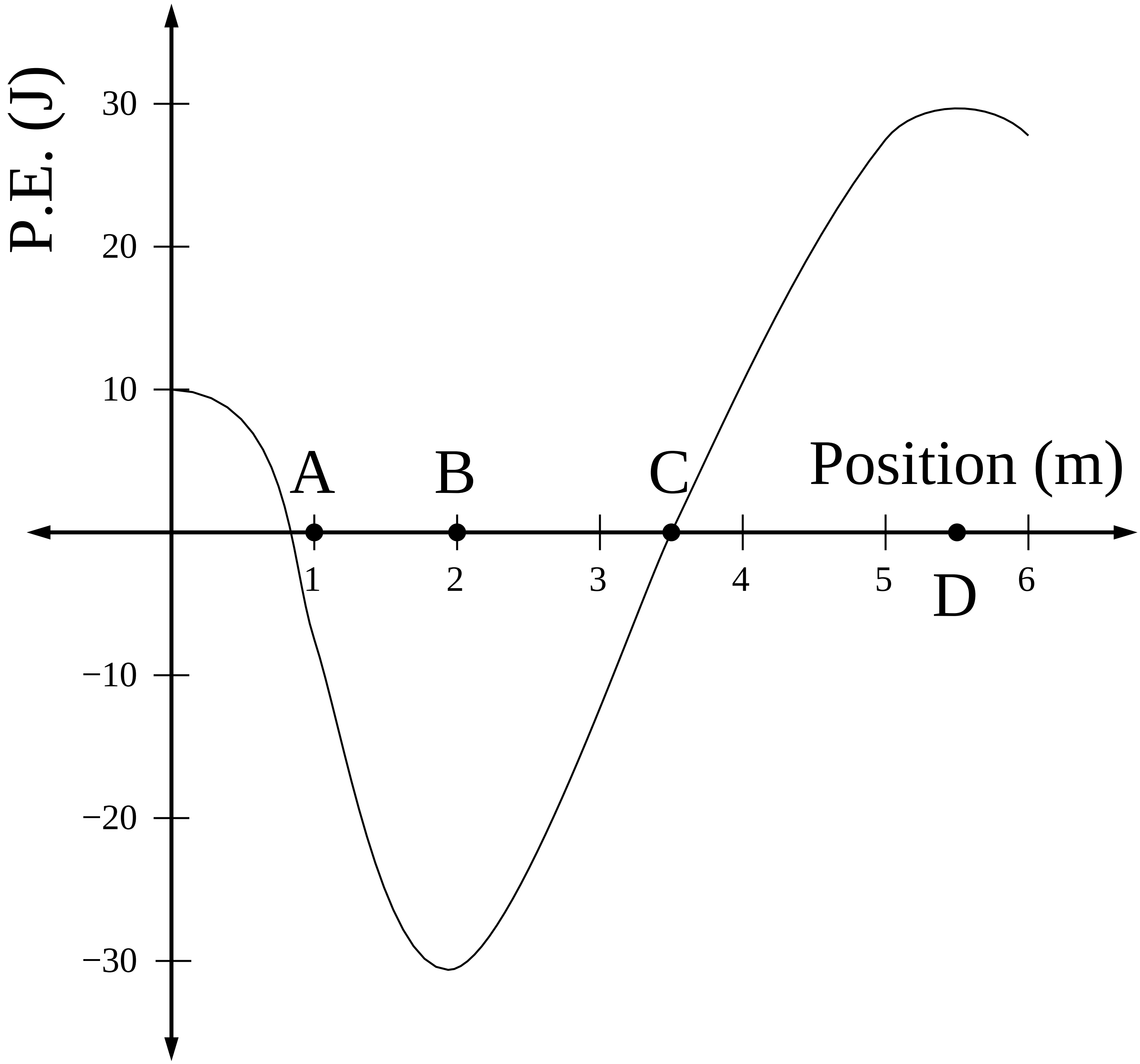


A) velocity and acceleration are zero

B) velocity is nonzero, but its acceleration is zero

C) acceleration is nonzero, but its velocity is zero

D) both are nonzero



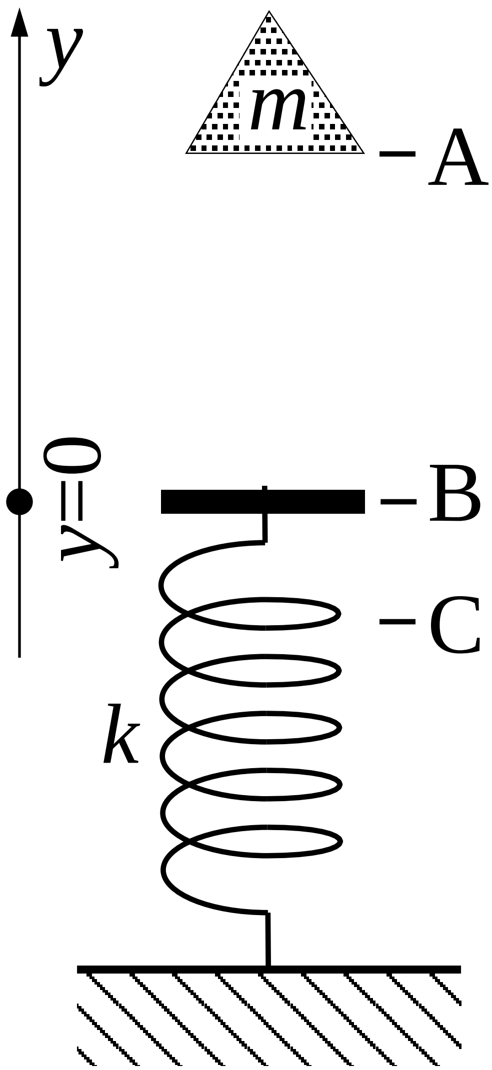
1) The force is zero at?:

2) The force is positive at?

3) The force is negative at?

4) Stable equilibrium at?

5) Unstable equilibrium at?



A mass *m* is released from the point **A**. At point **B** it hits a previously uncompressed spring. The spring slows the mass reaching a maximum compression at point **C**, before it starts to push the mass back up.

point D: none of the above

1) Where is the K.E. zero?

2) Where is the gravitational P.E. zero?

3) Where is the spring P.E. zero?

4) Where is the K.E. a maximum?

5) Where is the gravitational P.E. a maximum?

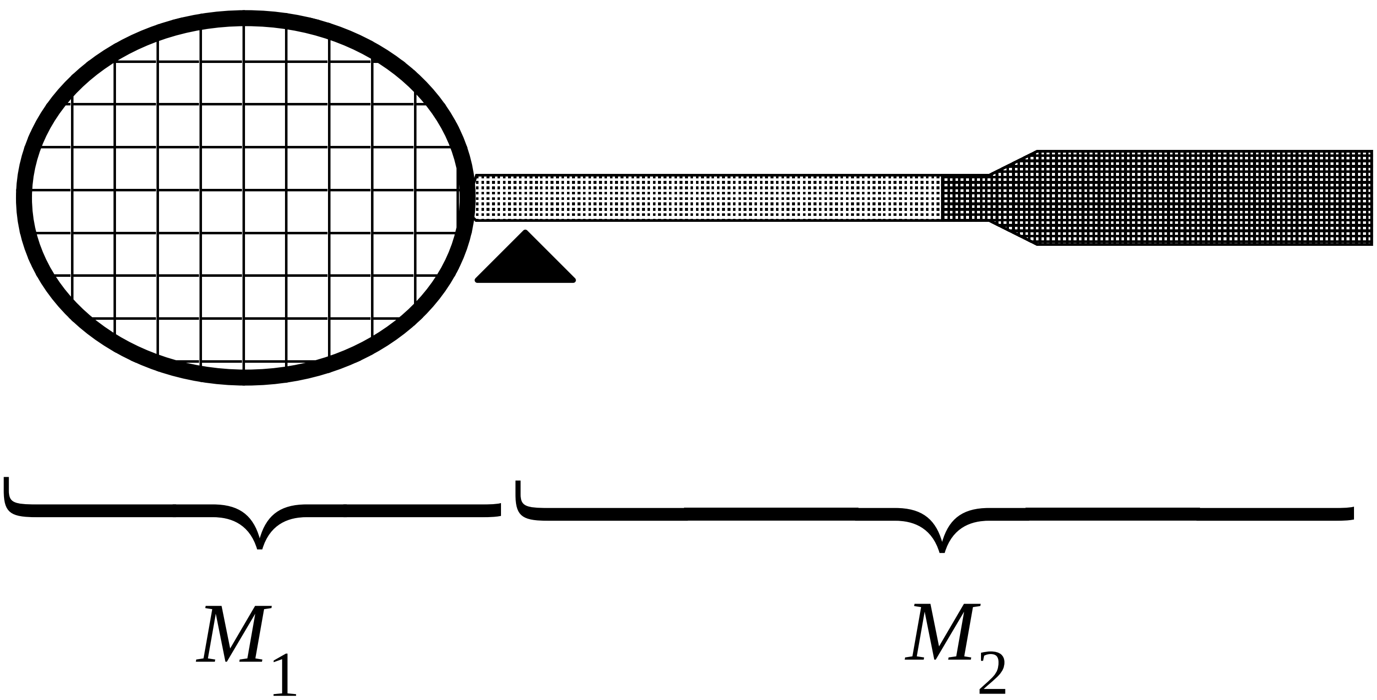
6) Where is the spring P.E. a maximum?

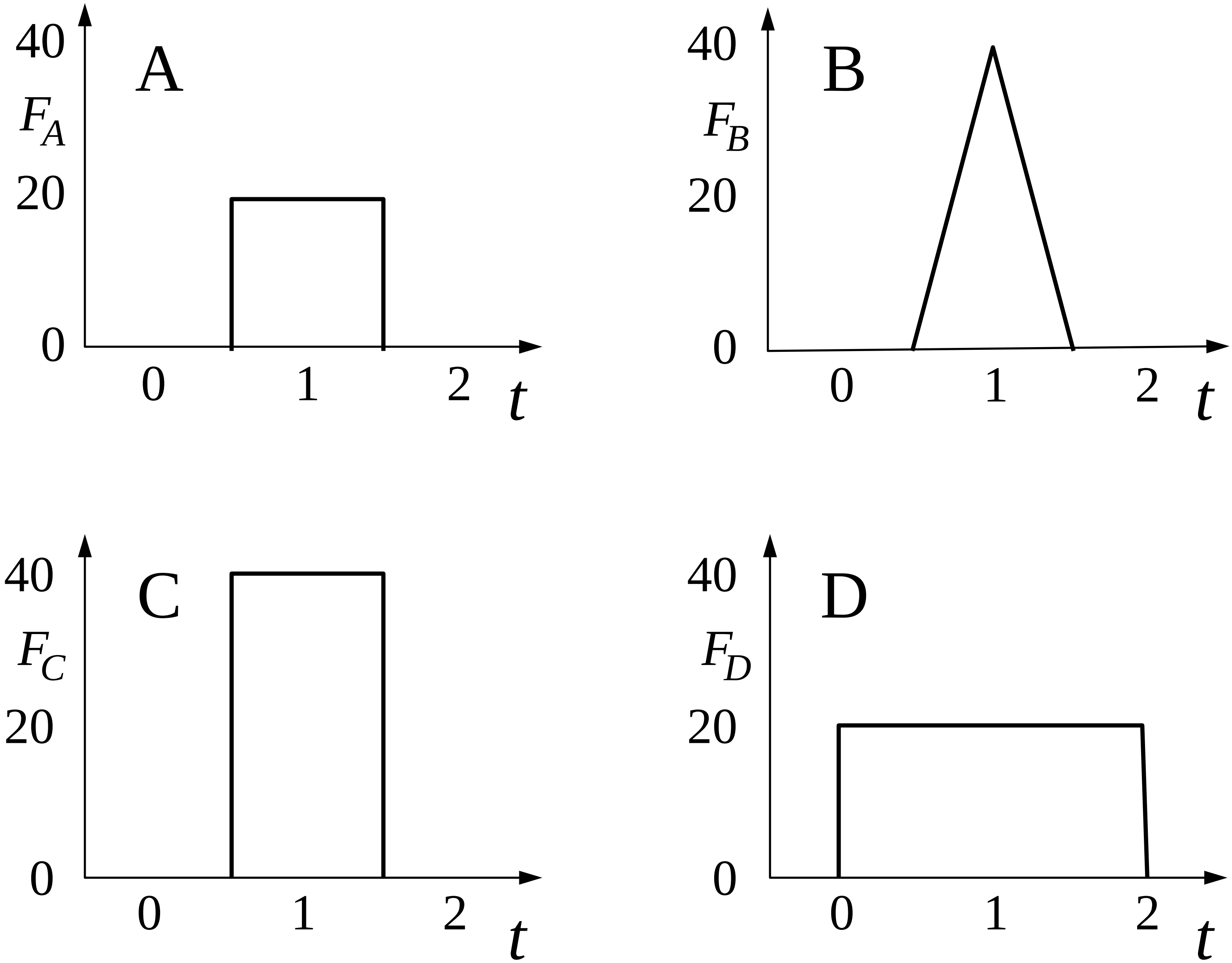
The below diagram shows a racket balanced on a point. How does the mass on one side of the balance point compare to the mass on the other?

A. $M_1 > M_2$

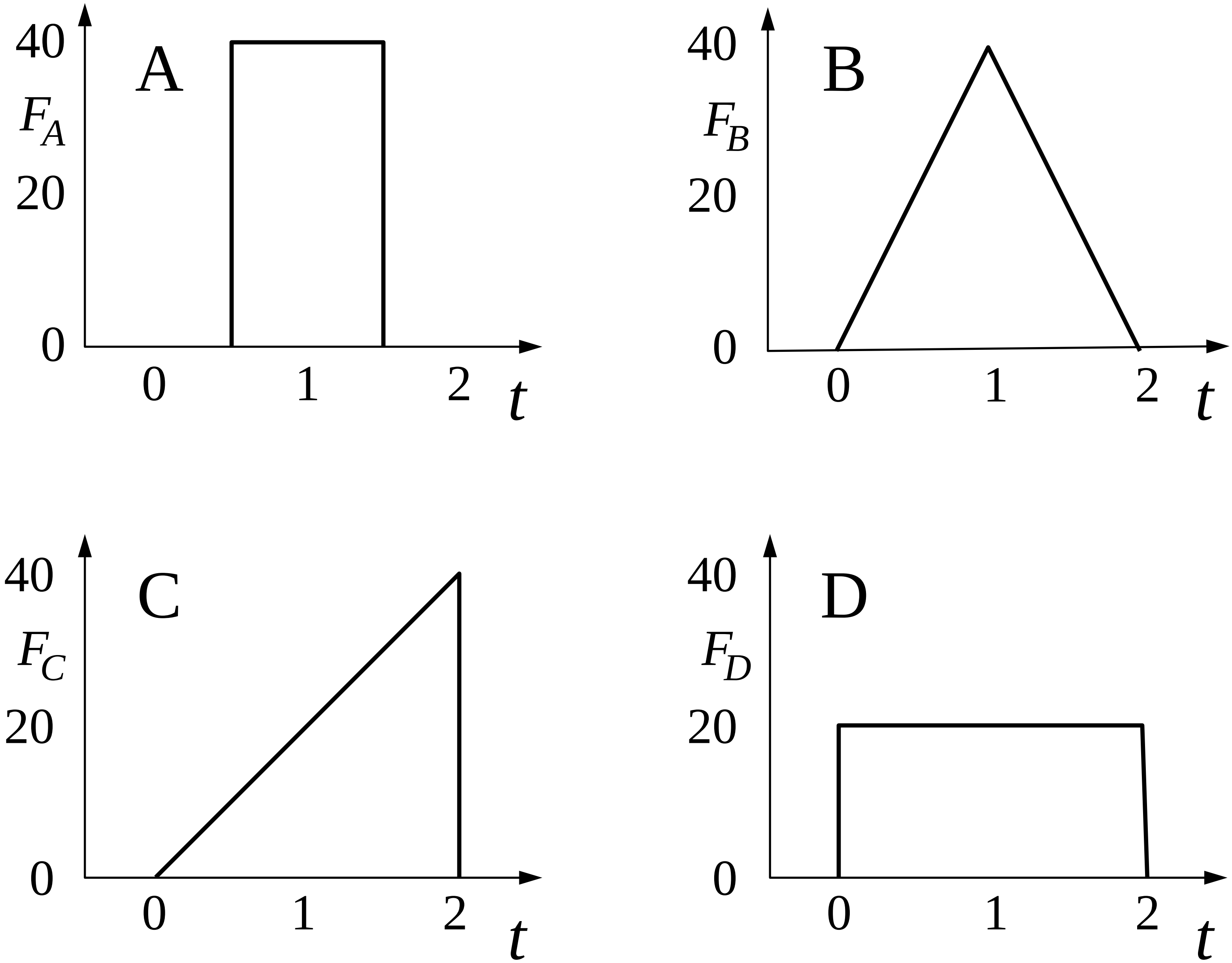
B. $M_1 = M_2$

C. $M_1 < M_2$

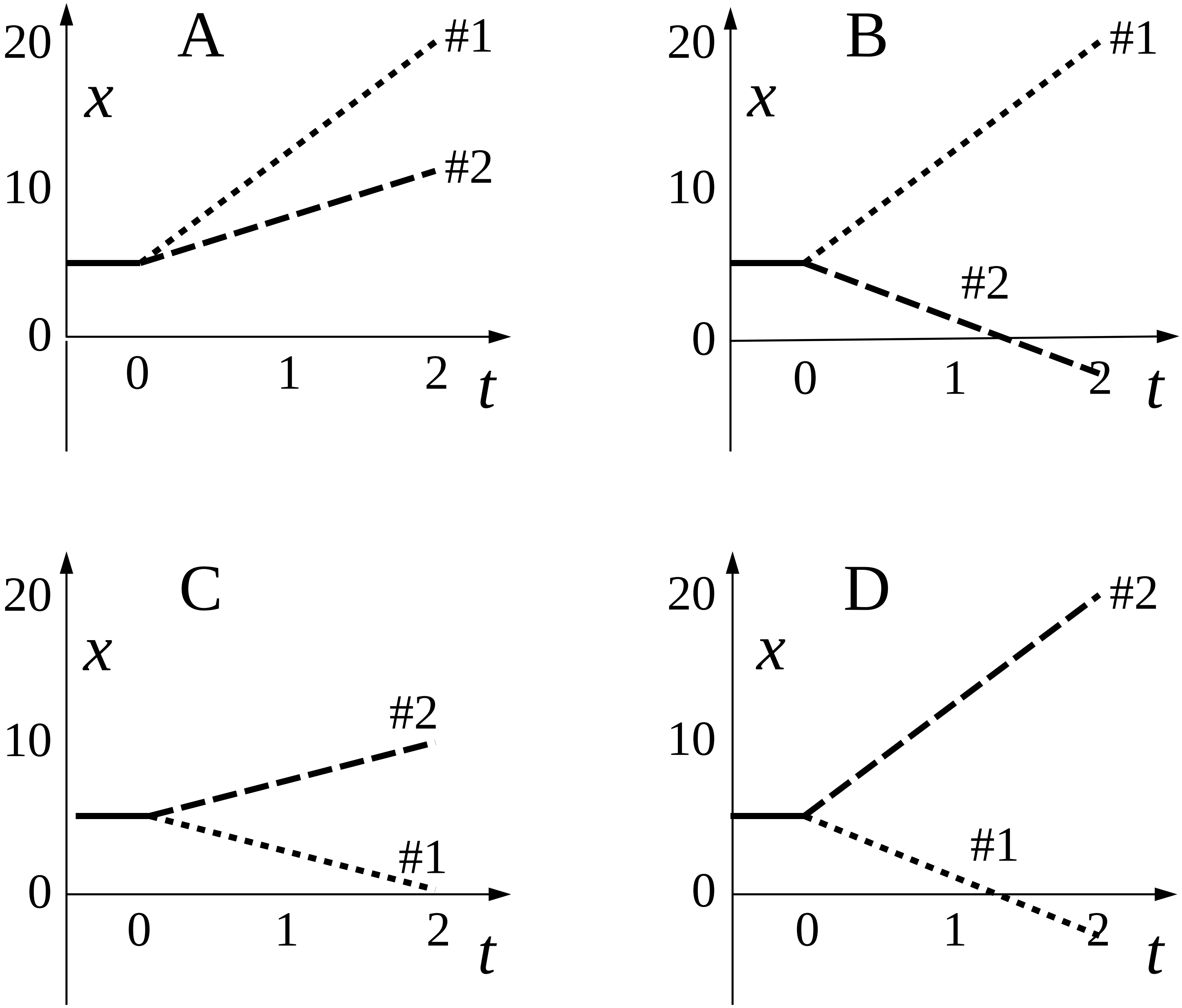




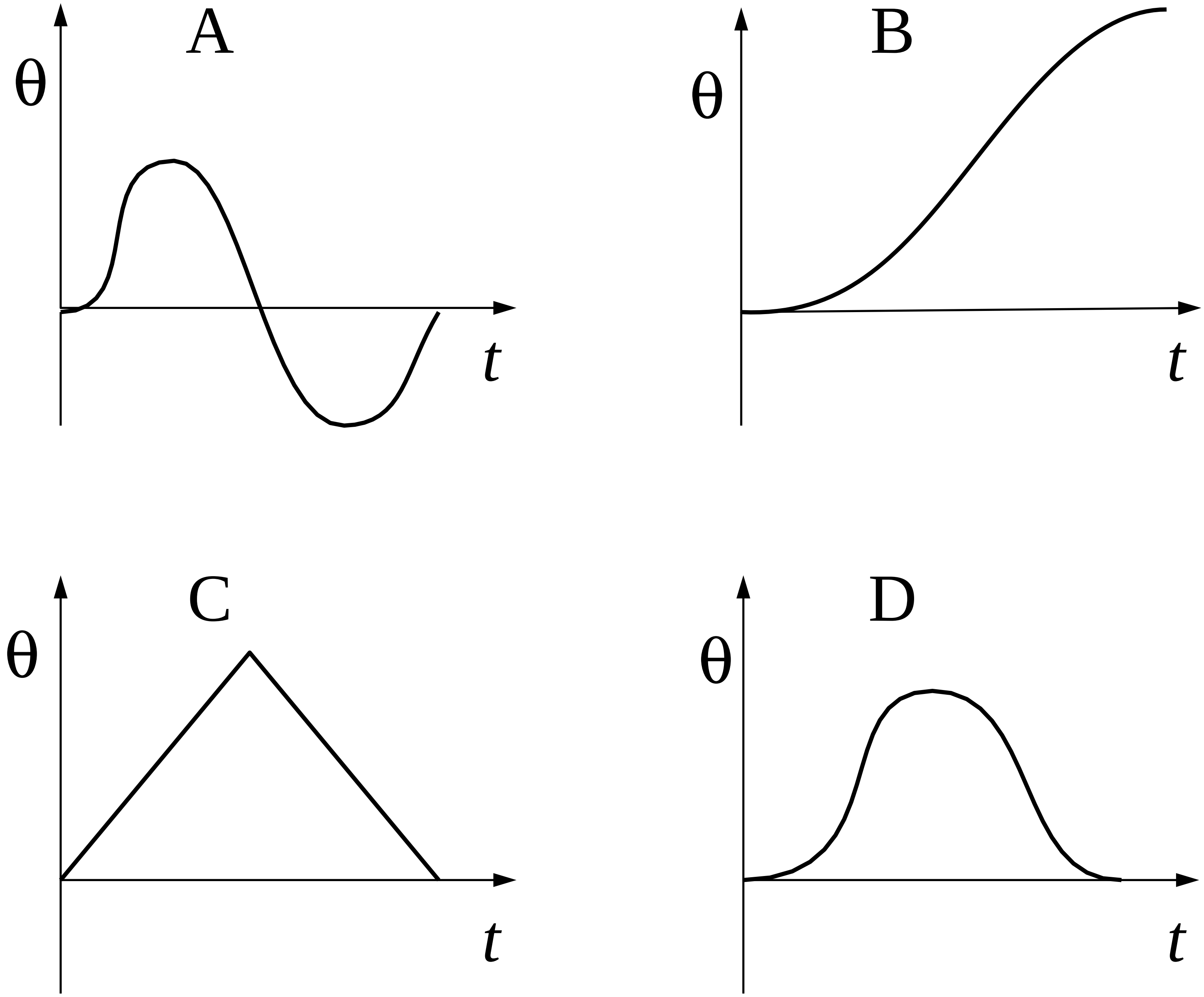
A
40
F_A
20
0
0
1
2
t
B
40
F_B
20
0
0
1
2
t
C
40
F_C
20
0
0
1
2
t
D
40
F_D
20
0
0
1
2
t

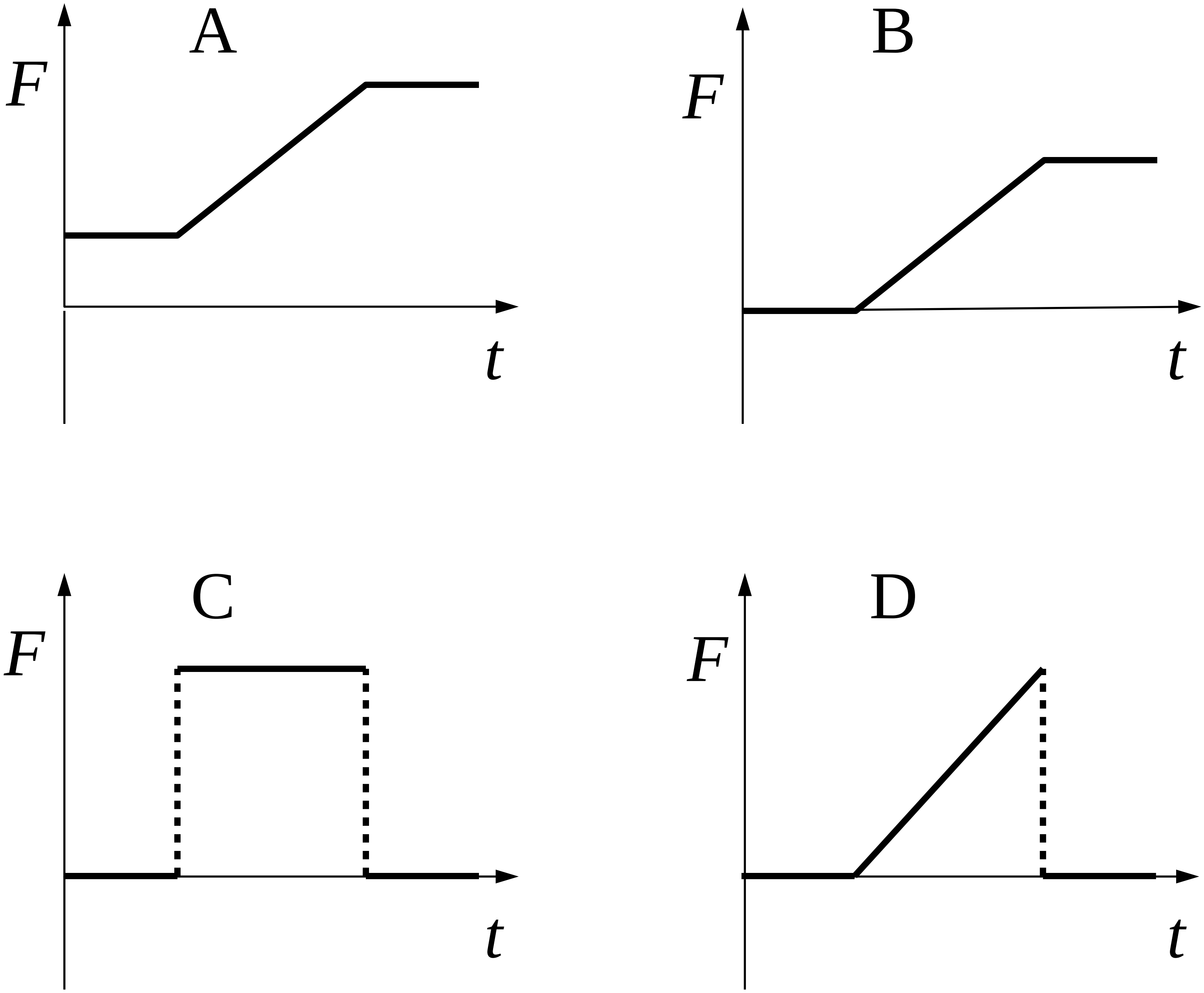


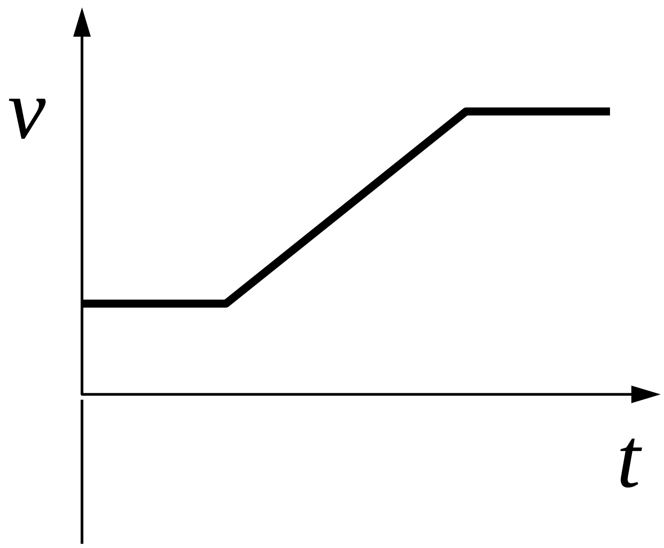
A
40
F_A
20
0
0
1
2
t
B
40
F_B
20
0
0
1
2
t
C
40
F_C
20
0
0
1
2
t
D
40
F_D
20
0
0
1
2
t

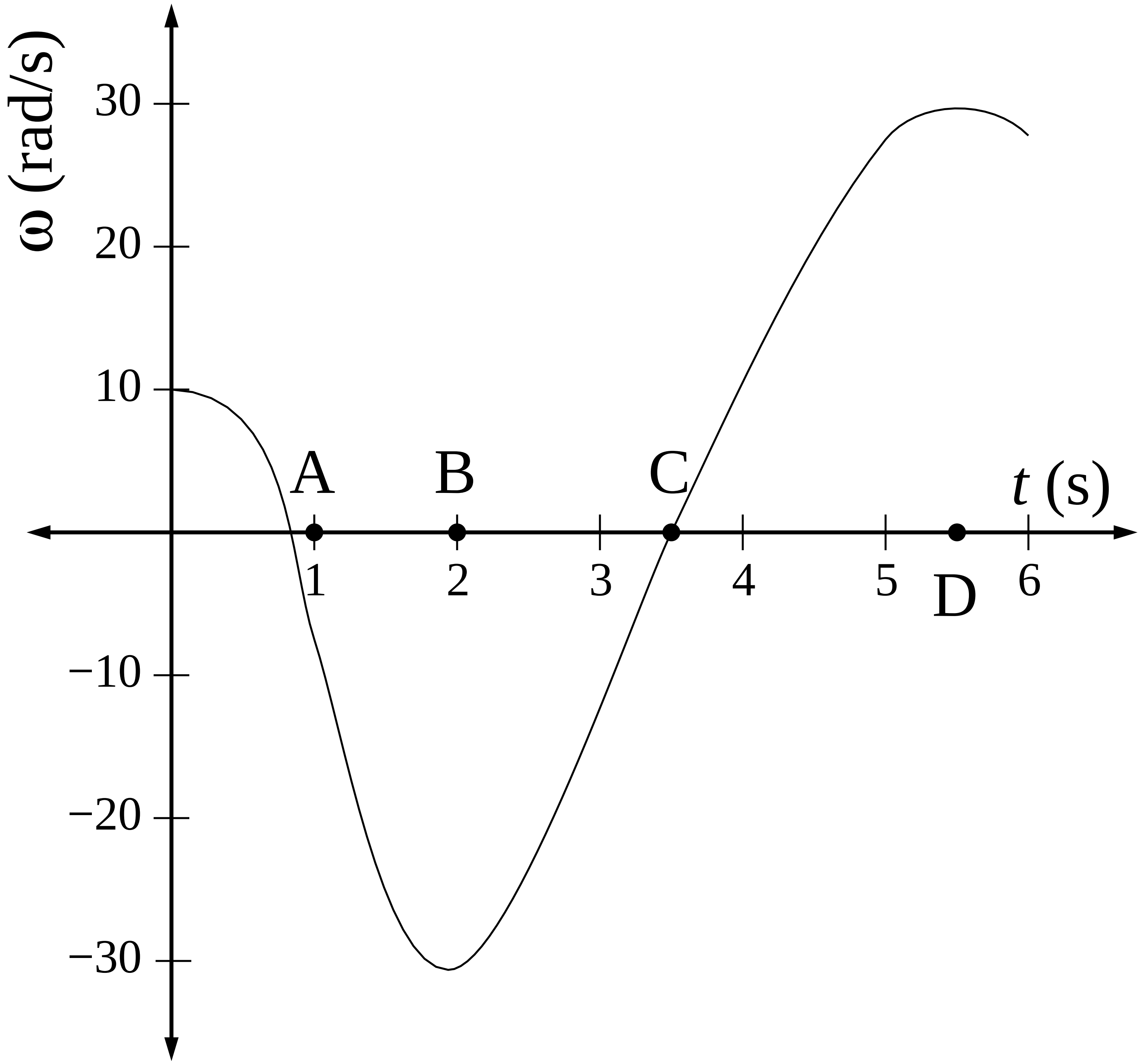


At *t*=0, an initially stationary box on a frictionless floor explodes into two pieces: piece #1 (dotted line) with mass 1 kg and piece #2 with mass 2 kg (dashed line). Which of the above graphs properly displays the positions of the pieces versus time.

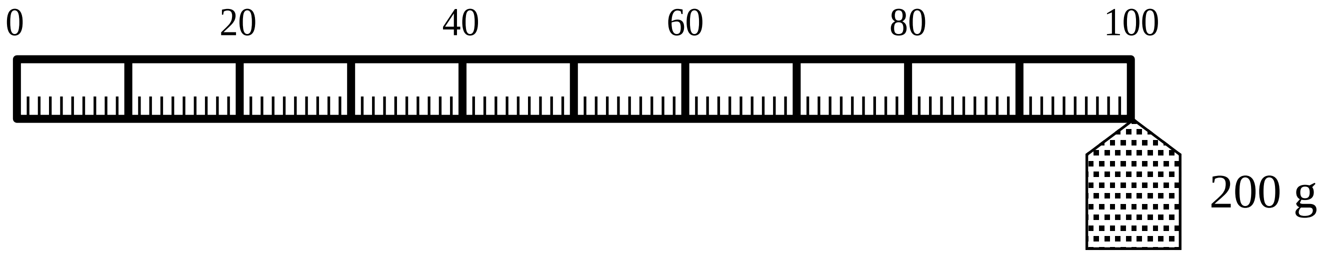

A
θ
t
B
θ
t
C
θ
t
D
θ
t


A
F
t
B
F
t
C
F
t
D
F
t


v
t



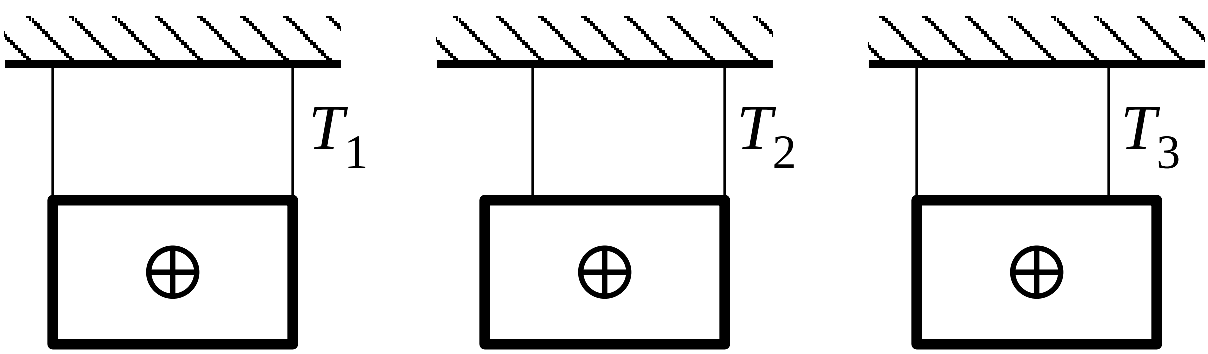
ω (rad/s)
30
20
10
−10
−20
−30
A
B
C
D
t (s)
1
2
3
4
5
6



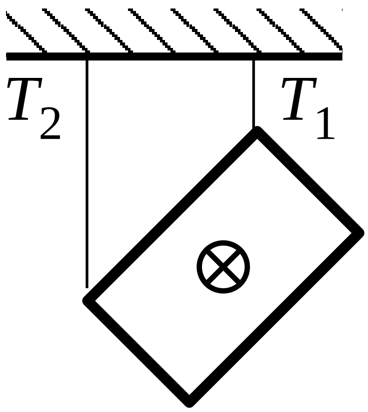
A 200 g mass is placed at the 100 cm mark of a 200 g meter stick. The system will be balanced if the fulcrum is placed:

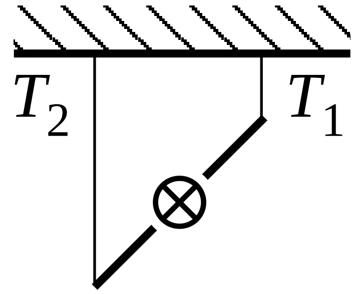
A. 50 cm mark
B. 66 2/3 cm mark
C. 75 cm mark
D. None of the above

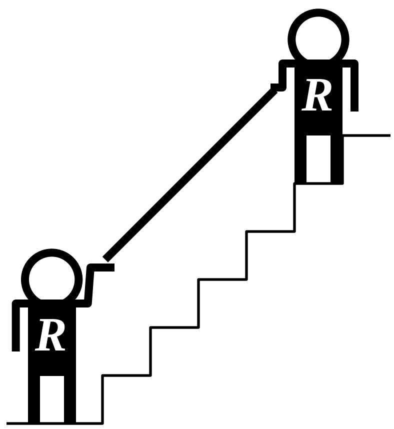
A picture is to be hung from the ceiling by means of two wires. Three different situations are considered (see below) . Rank the right wire tension in the three situations from least to greatest. The center of mass of the picture (labeled below ⊕) is in the center of the picture.

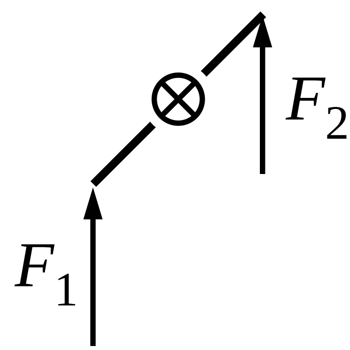


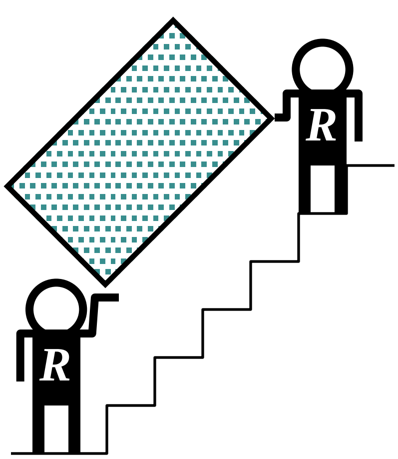
A. $T_1 < T_2 < T_3$
B. $T_2 < T_1 < T_3$
C. $T_3 < T_1 < T_2$
D. None of the above

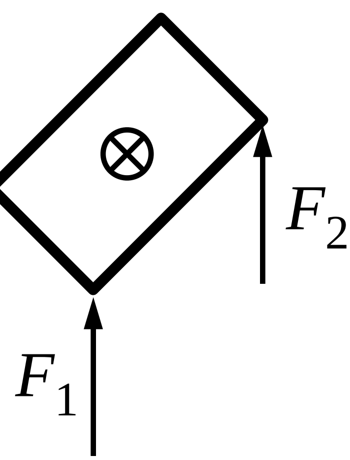

T2
T1


T2
T1

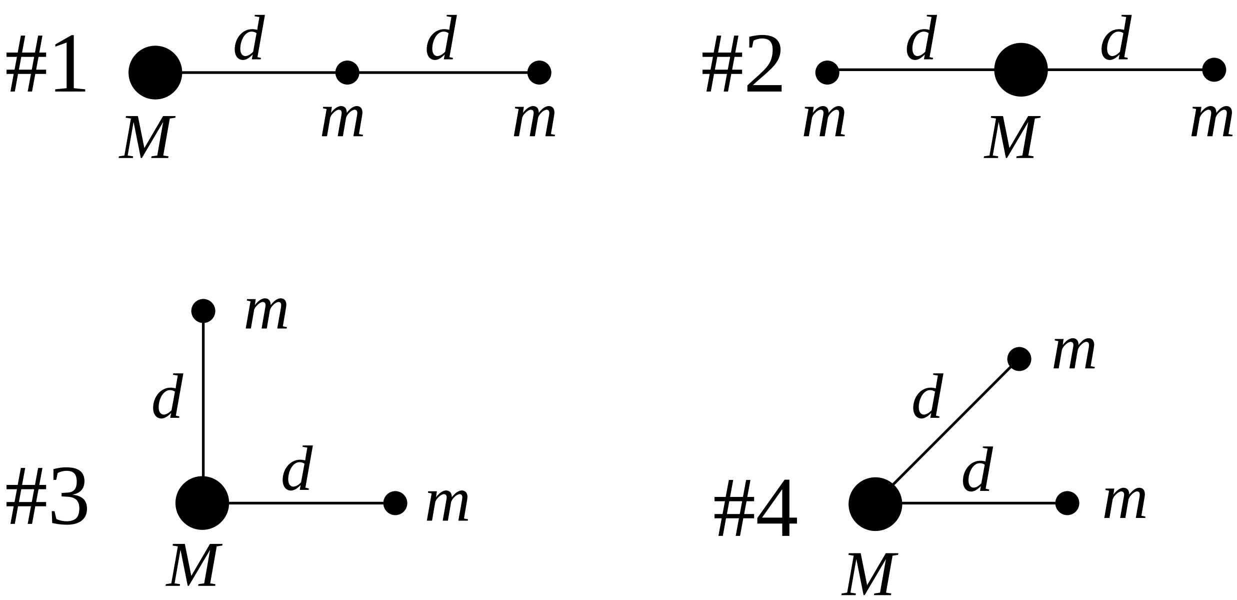

R
R


F2
F1


R
R


F2
F1

Three particles, two with mass *m* and one with mass *M*, might be arranged in any of the four configurations shown below. Rank the configurations according to the magnitude of the gravitational force on *M*, least to greatest.

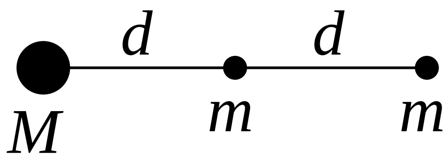


A. 1,2,3,4
B. 2,1,3,4
C. 2,1,4,3
D. 2,3,4,1

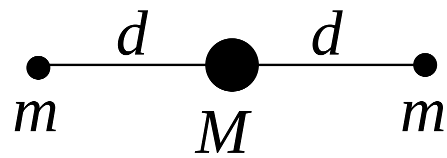
An astronaut is orbiting the Earth in the space shuttle. She feels "weightless" because:

A. she is beyond the range of gravity
B. centrifugal force is equal but opposite to gravity
C. she has no acceleration
D. the shuttle is falling at the same rate she is

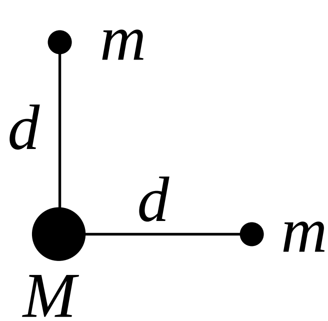
#1



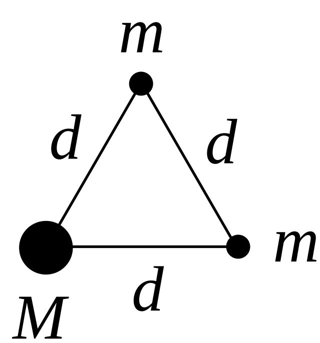
#2

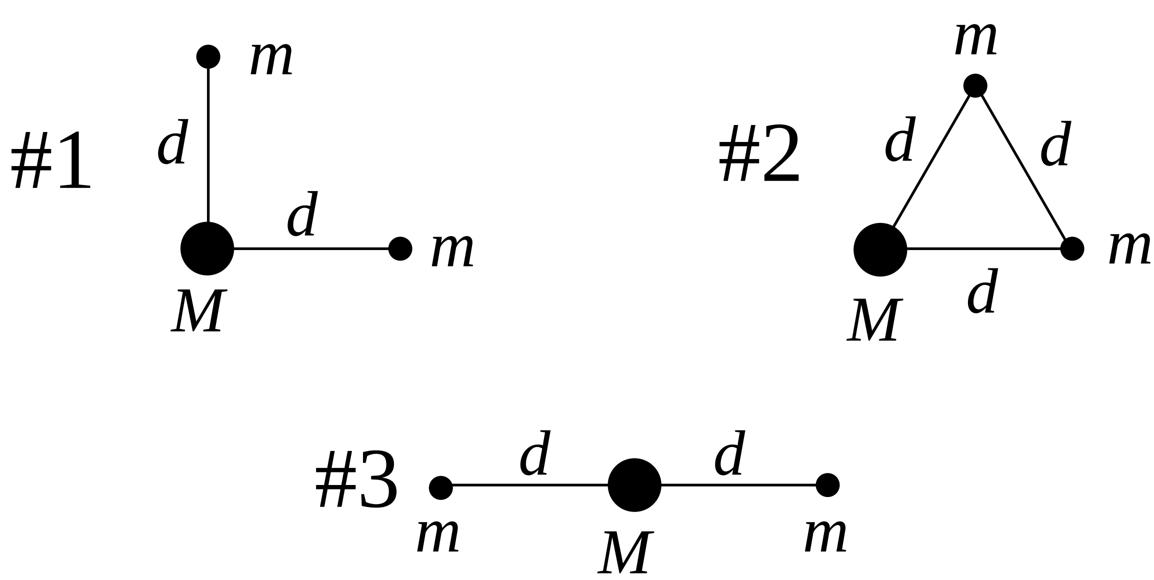


#3

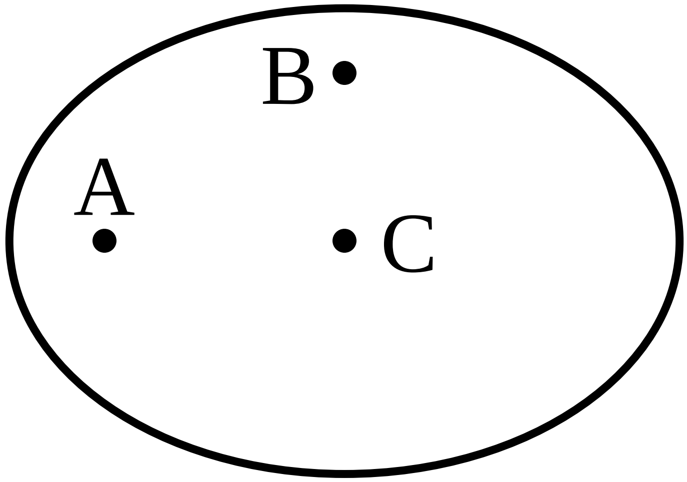


#4

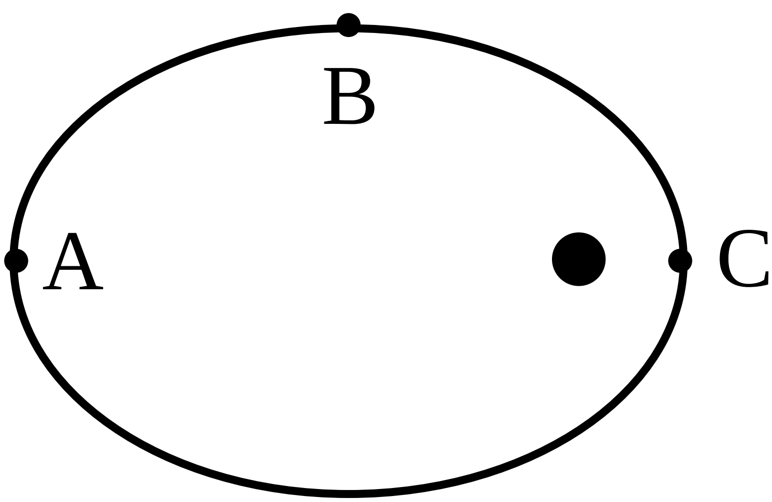



#1
m
d
d
m
M
#2
m
d
d
m
M
d
#3
d
d
m
M
m

The elliptical orbit of a meteoroid around the Sun is shown below.
Where is the Sun located?



D: none of the above



D: none of the above

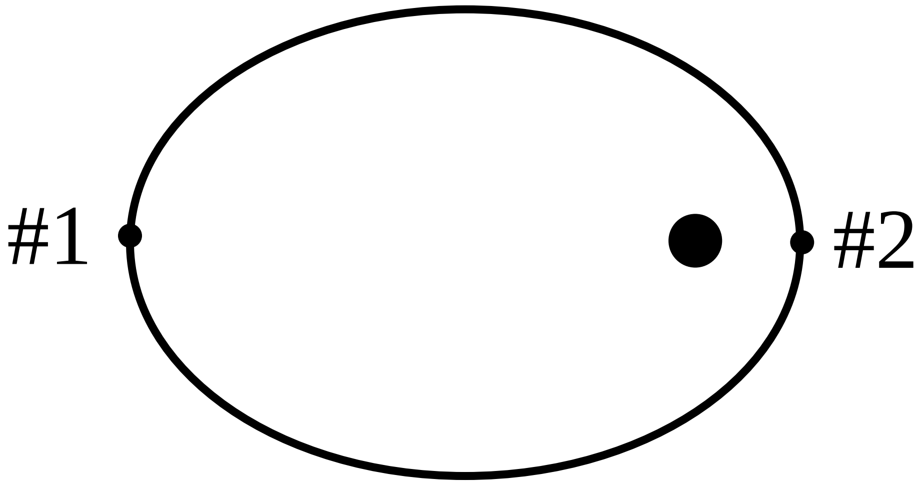
1) Where is the P.E. the least?

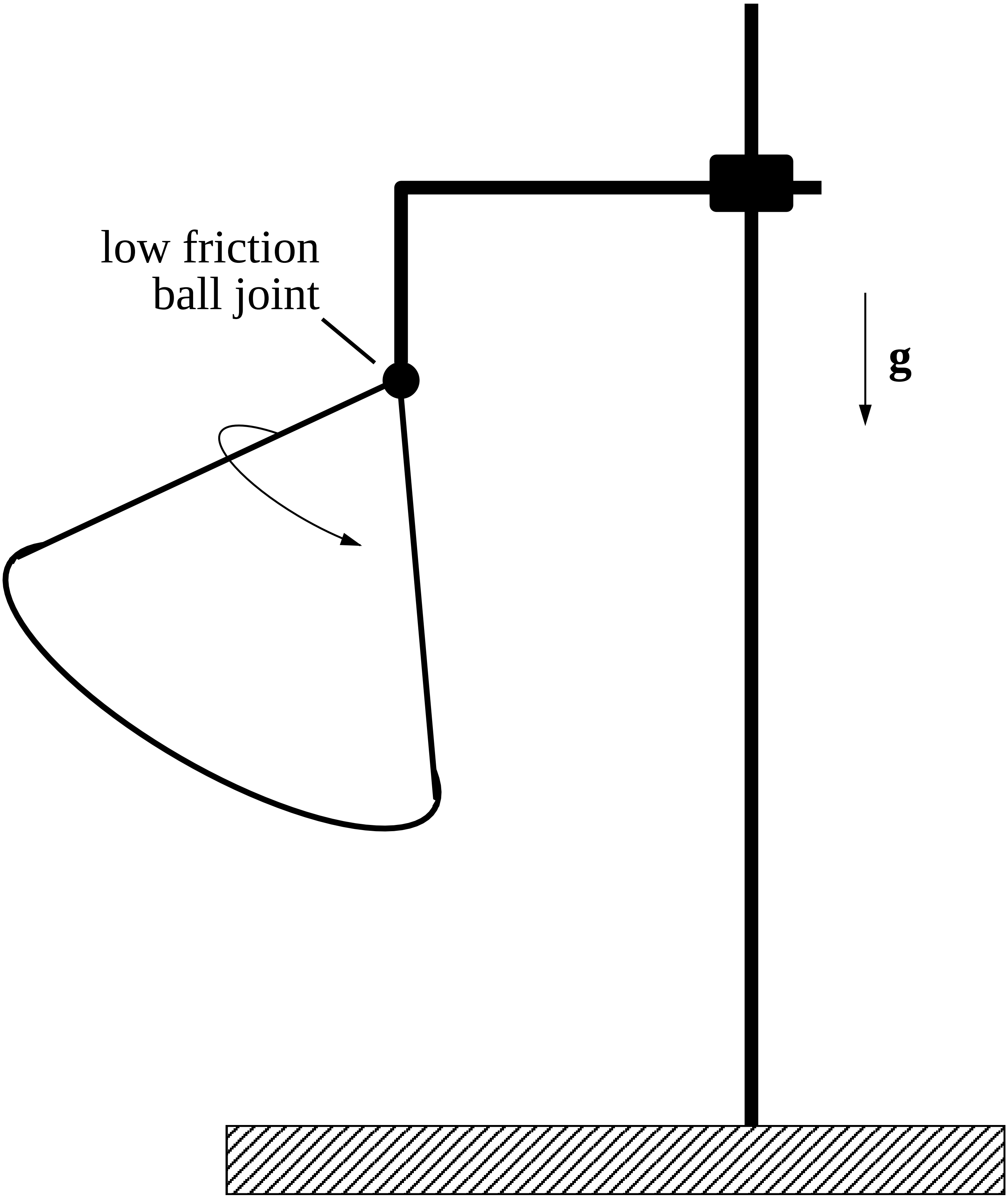
2) Where is the speed. the least?

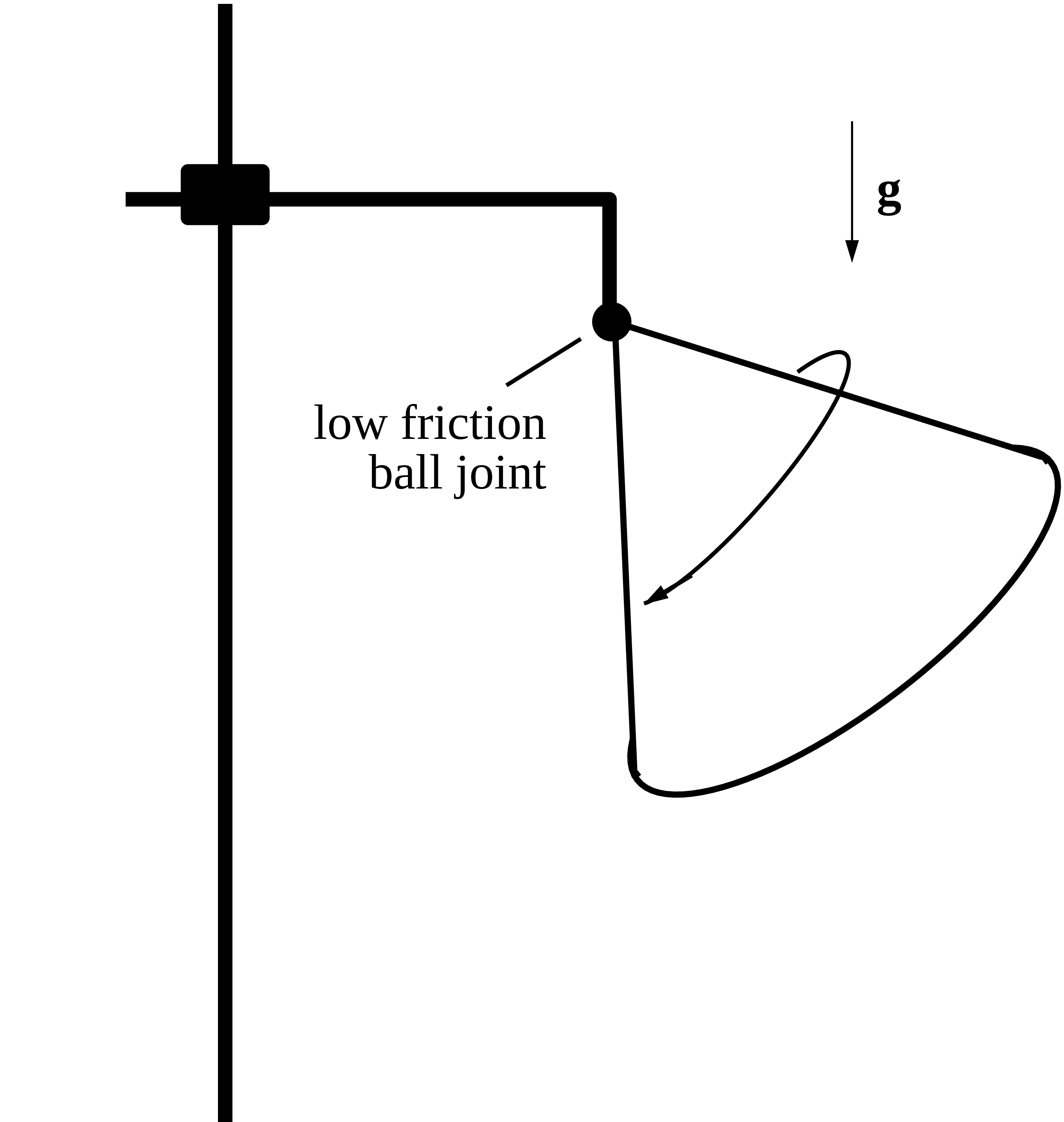
3) Where is the angular momentum the least?

4) Where is the angular speed the least?

4) Where is the acceleration the least?


#1
#2

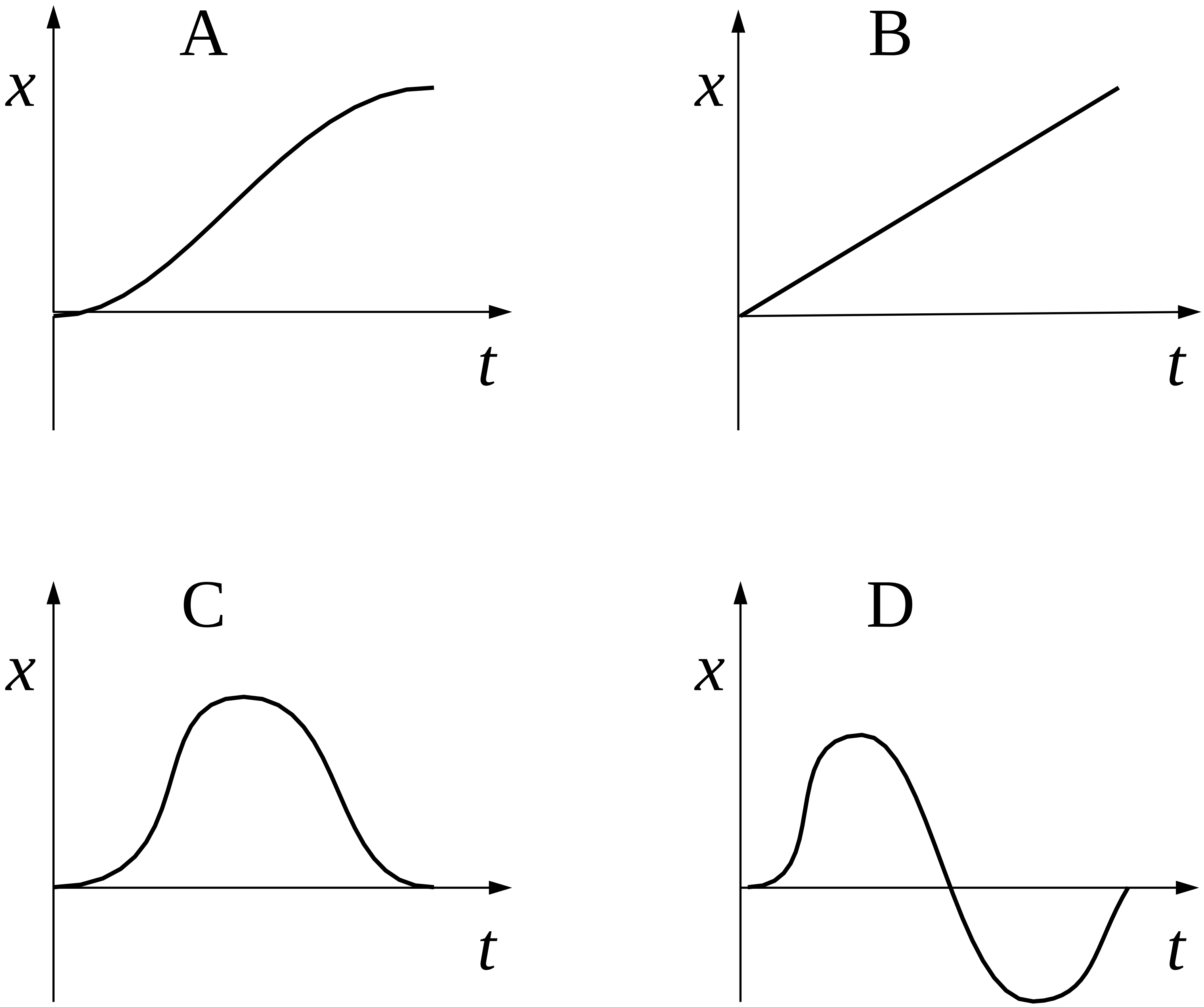

low friction
ball joint
g


g
low friction
ball joint

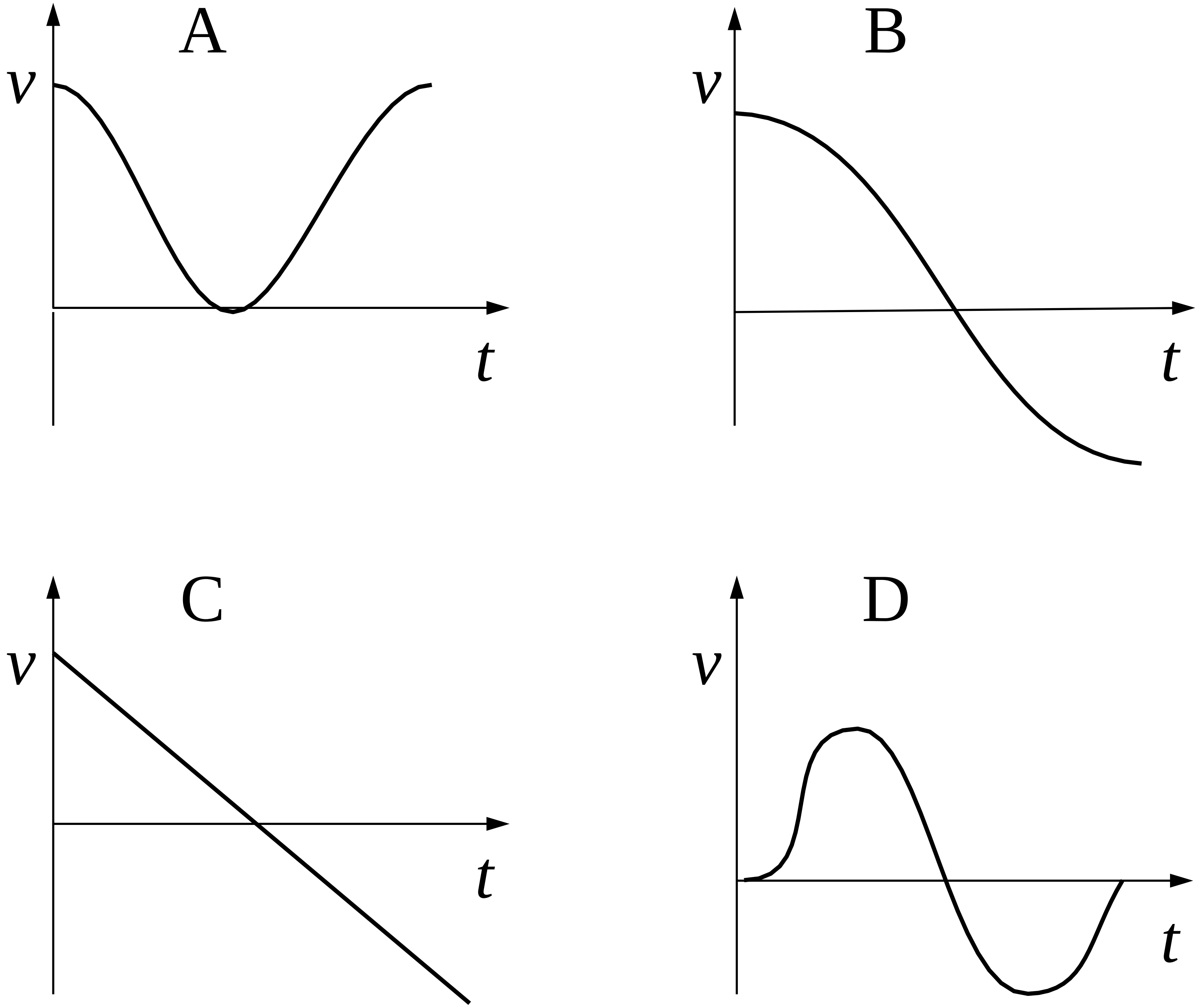
How many of the below numbers display exactly three (3) significant digits?

- .009
- 700
- 0.72
- 5.20
- 2002.1
- 0.720

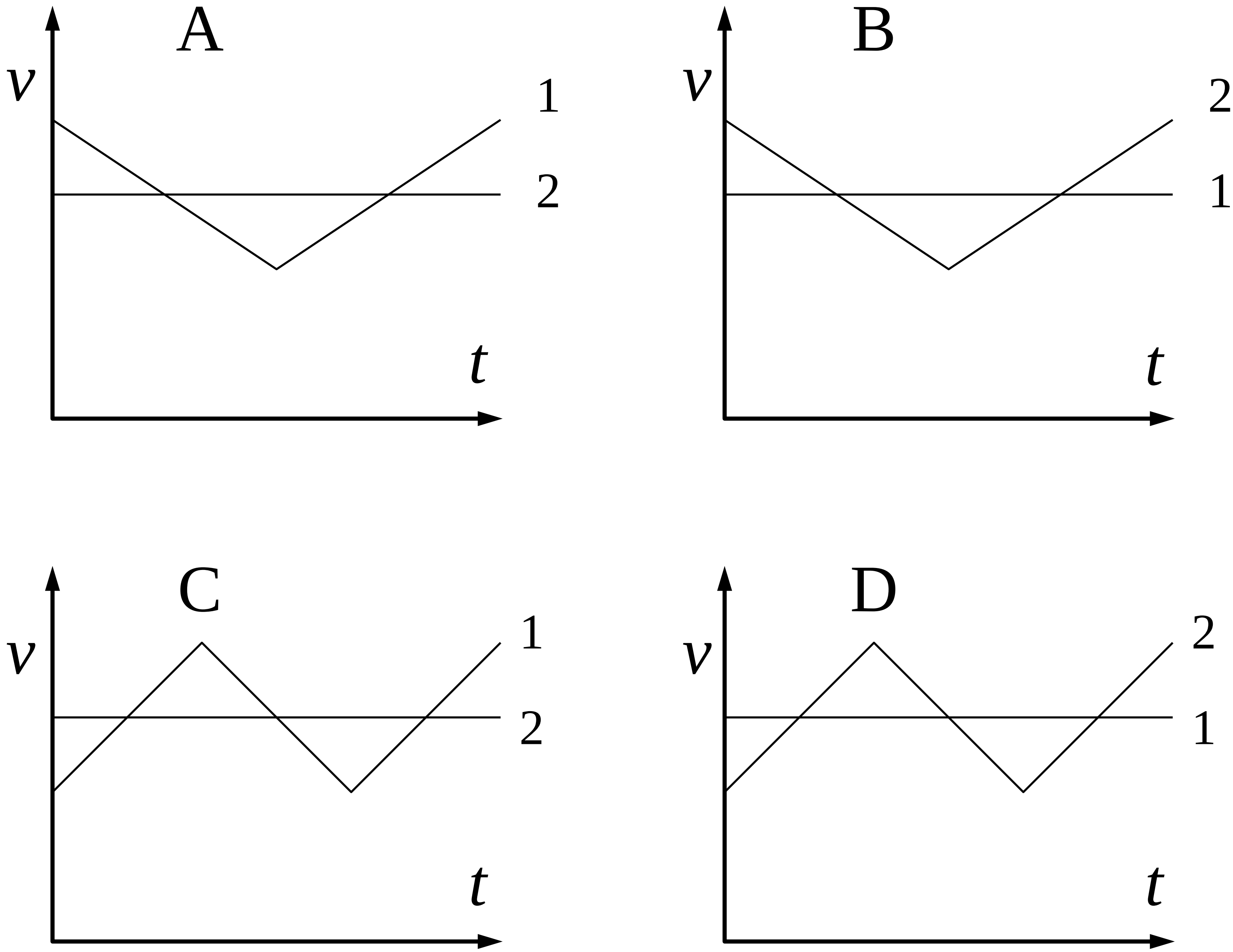
A. One
B. Two
C. Three
D. None of the above

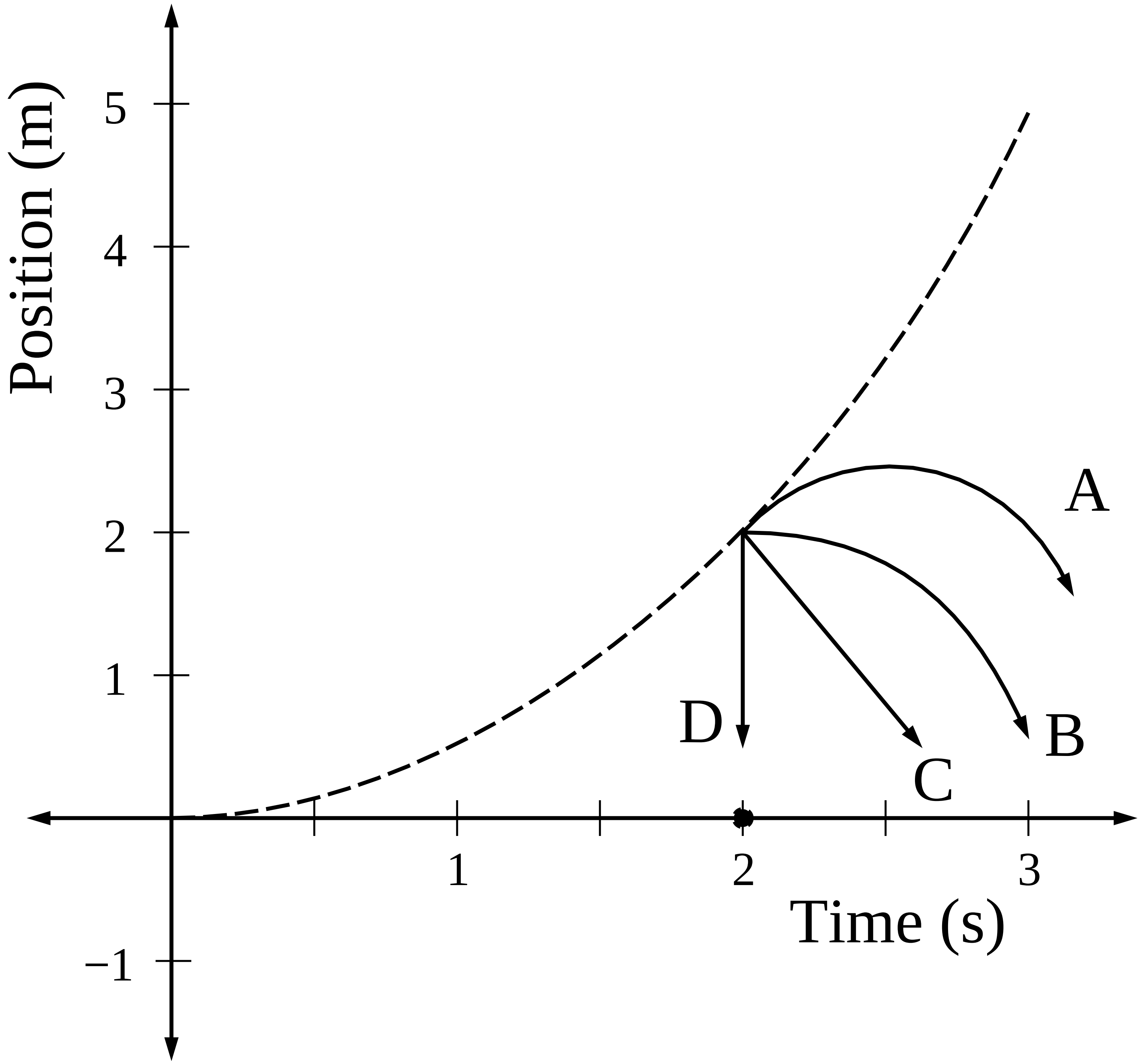


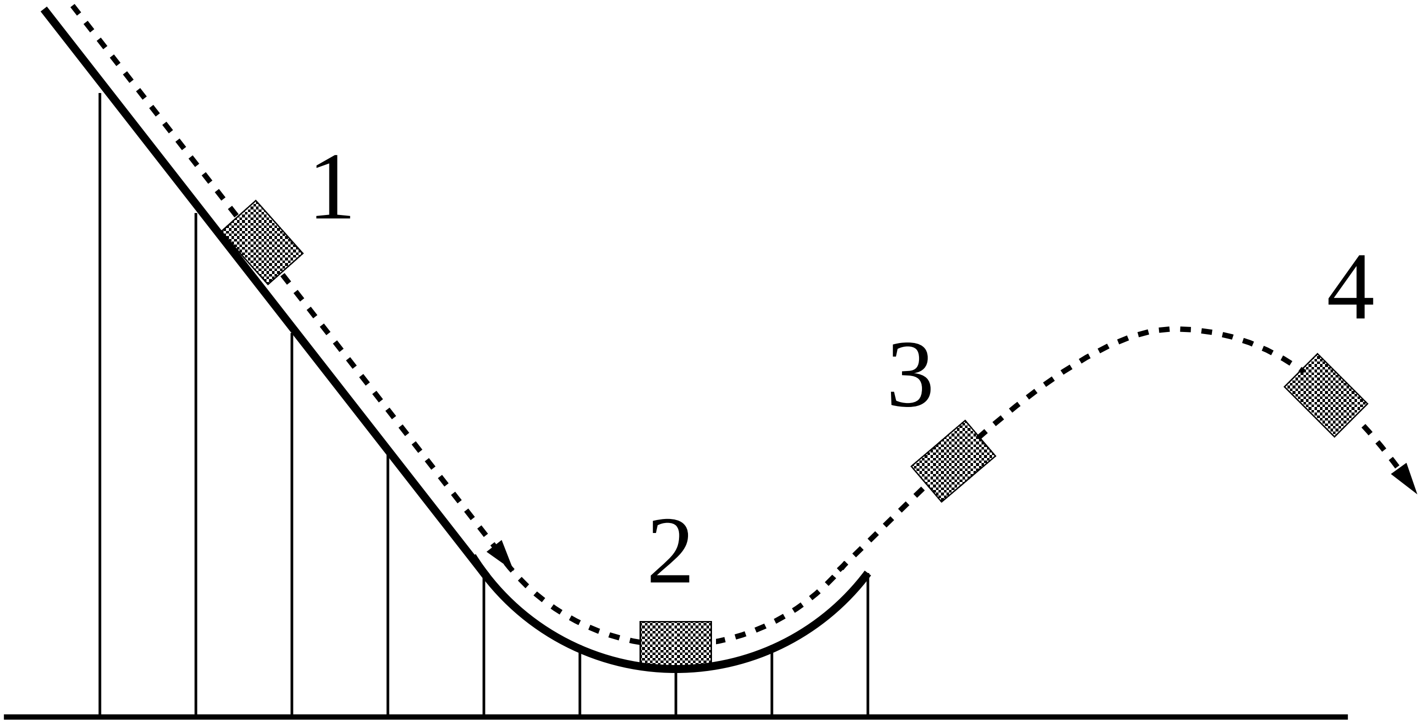
Starting from rest, a car accelerates down a straight road. A short time later the driver applies the brakes, and the car comes to a stop. Which of the above graphs of position vs. time best displays this motion?



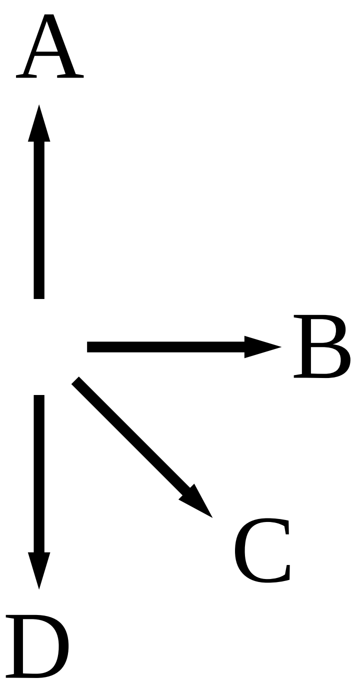
A boy throws a steel ball straight up
Which of the above graphs of veloc
vs. time best displays this motion?

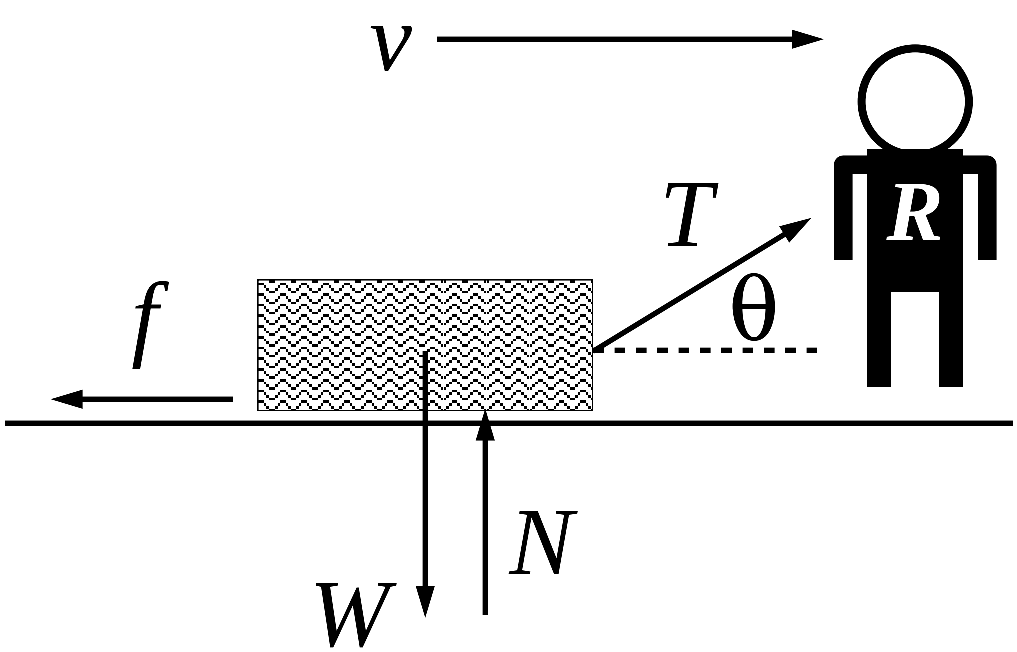

A
v
1
2
t
B
v
2
1
t
C
v
1
2
t
D
v
2
1
t


Position (m)
5
4
3
2
1
−1
A
B
C
D
1
2
3
Time (s)



A package slides down a frictionless "ski jump". In which direction is the package's acceleration?





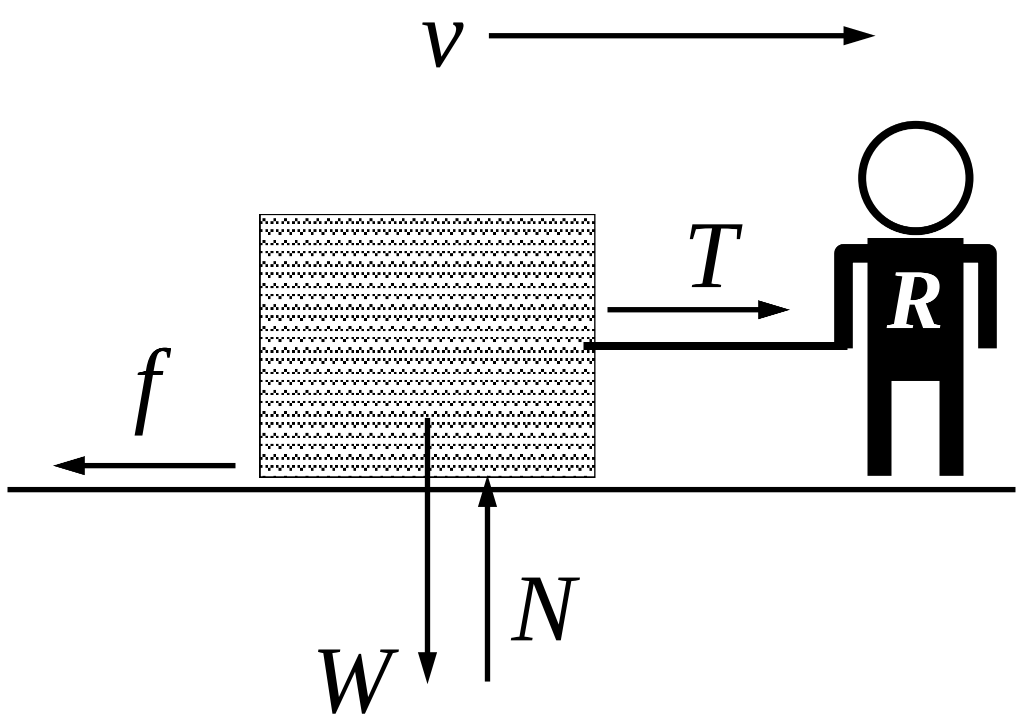
Rupert pulls a box across a horizontal surface at a constant velocity *v*, by pulling on a rope with tension *T*. Other forces (*W*: gravity, *N*: normal force, *f*: friction) act in the directions indicated. Which of the following relations among the force magnitudes must be true?

A. $T=f$ and $N=W$

B. $T>f$ and $N<W$

C. $T>f$ and $N=W$

D. $T=f$ and $N<W$



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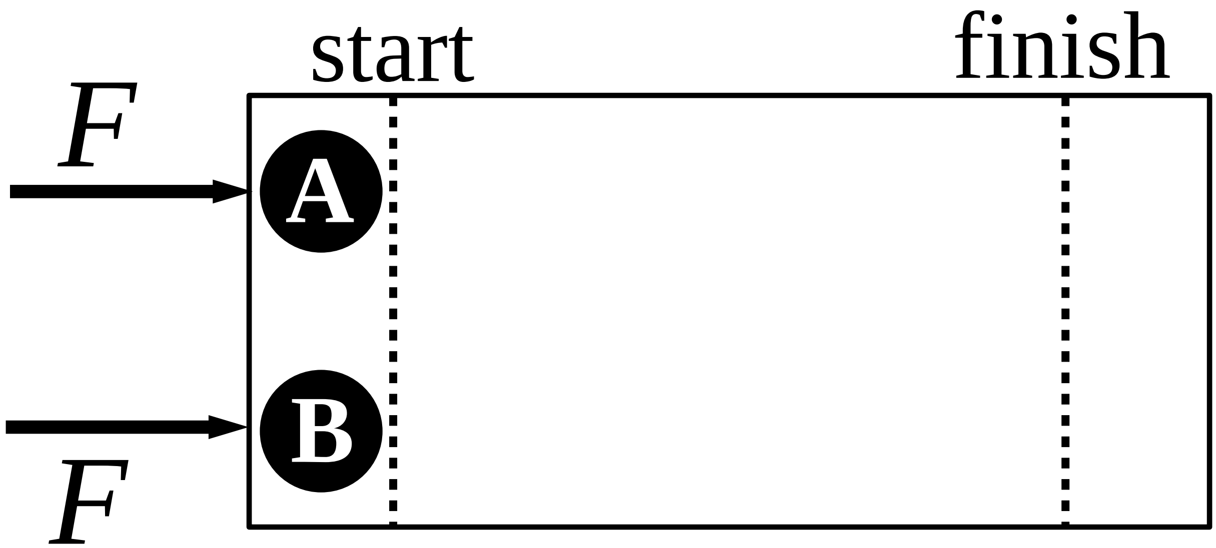
A. $T=f$ and $N=W$

B. $T>f$ and $N<W$

C. $T>f$ and $N=W$

D. $T=f$ and $N<W$



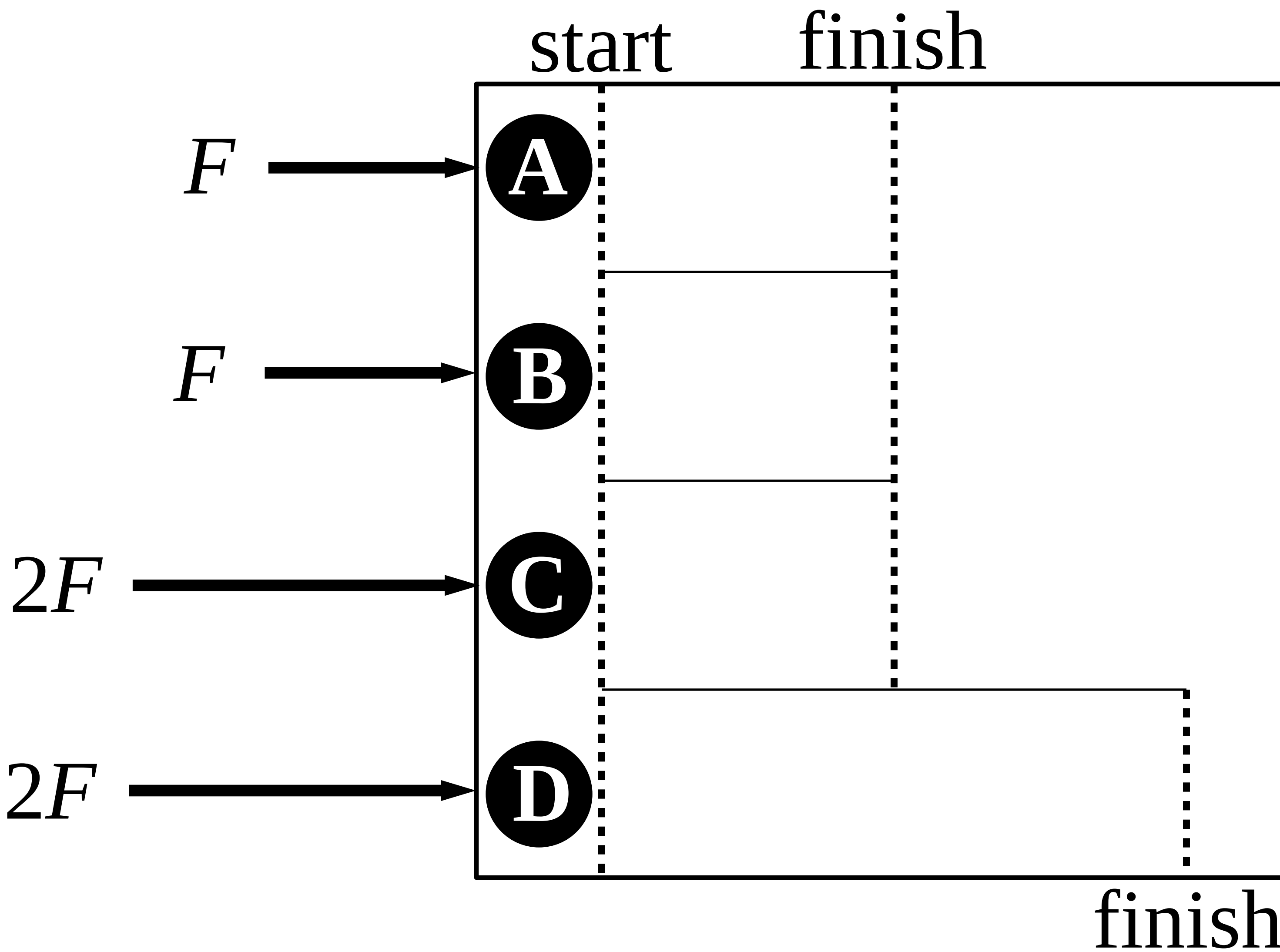
Two hockey pucks race on a frictionless surface. Puck **A** is made of lead; Puck **B** is made of rubber. Starting from rest, the pucks are pushed from start to finish by equal forces *F*.

1) Which puck wins the race?

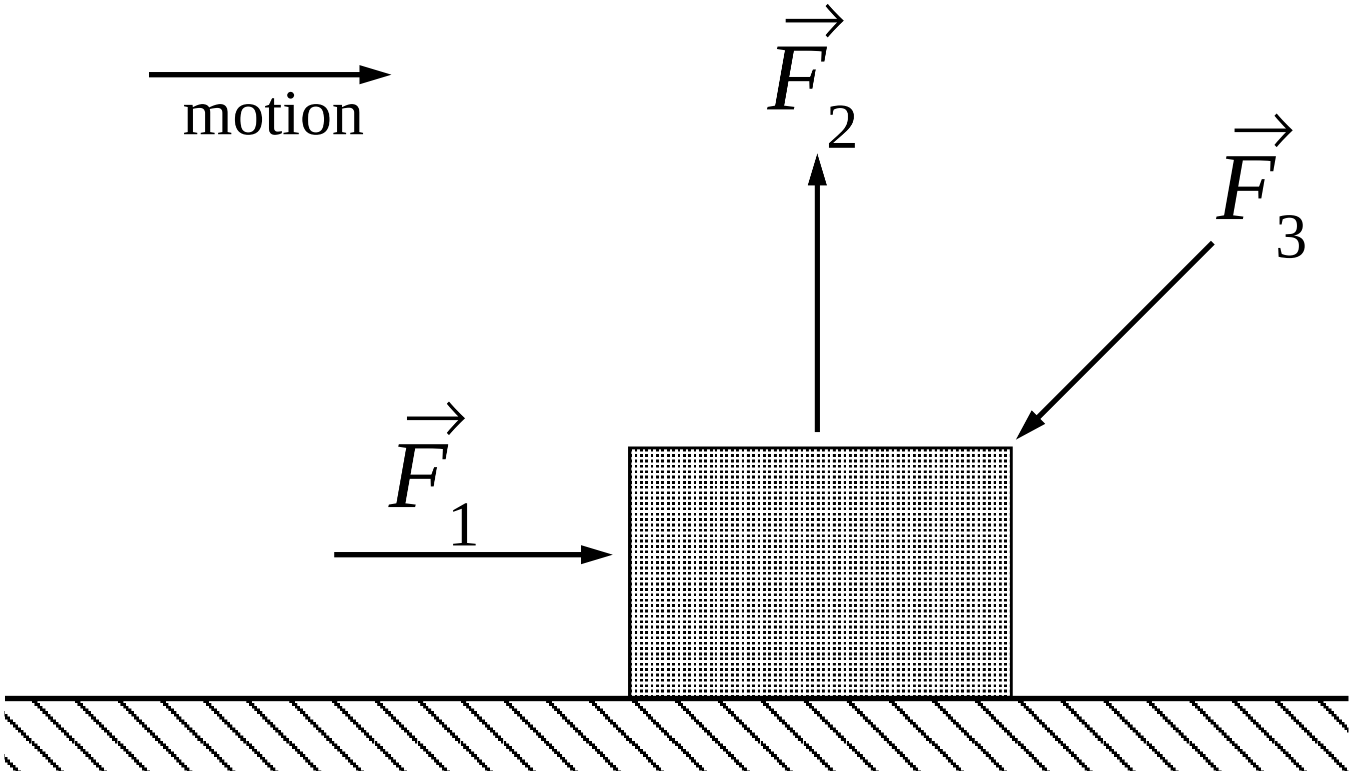
2) Which force does more work?

3) Which puck has more KE when it crosses the finish line?

4) Which puck has more momentum when it crosses the finish line?



Four pucks race on a frictionless surface. The pucks have masses: M_A=1, M_B=2, M_C=3, M_D=4 (each in kg). As shown above, they are subjected to different forces and race lengths. Which puck has the largest kinetic energy when it crosses its finish line?



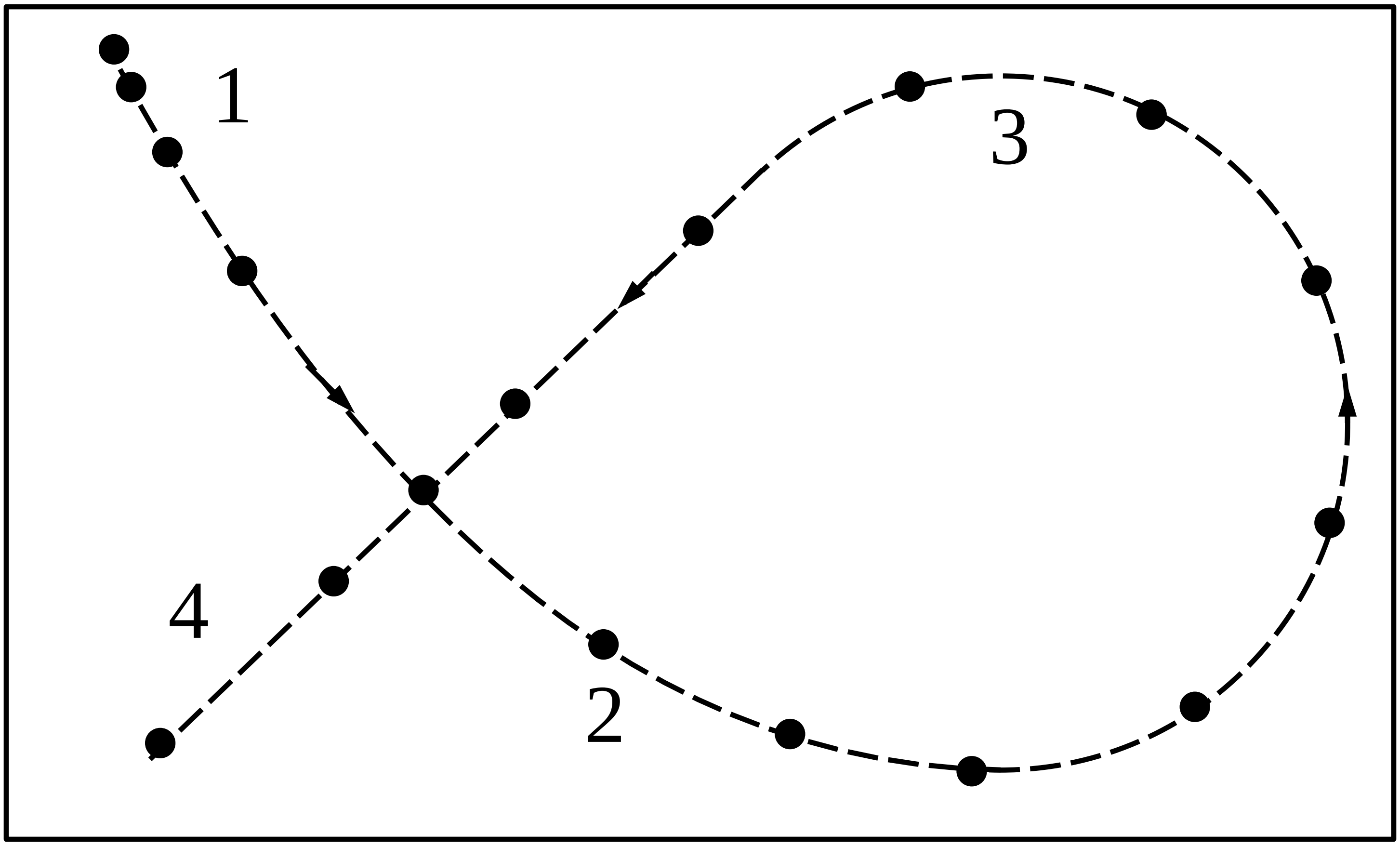
Three forces of equal magnitude but different direction act on a block as shown above. The block moves 3 m to the right. Rank the work done by each force. (The work done by force F_1 is W_1, etc.)

A. $W_1 > W_2 > W_3$

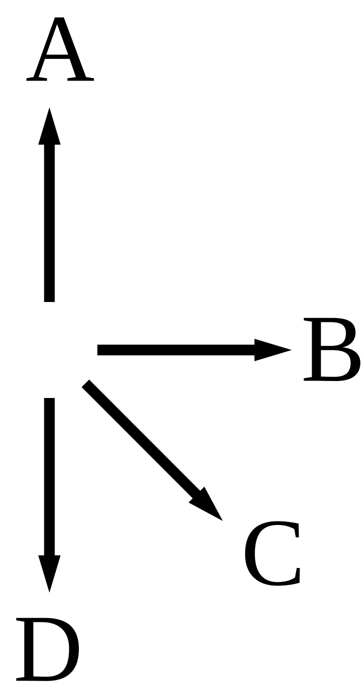
B. $W_2 > W_3 > W_1$

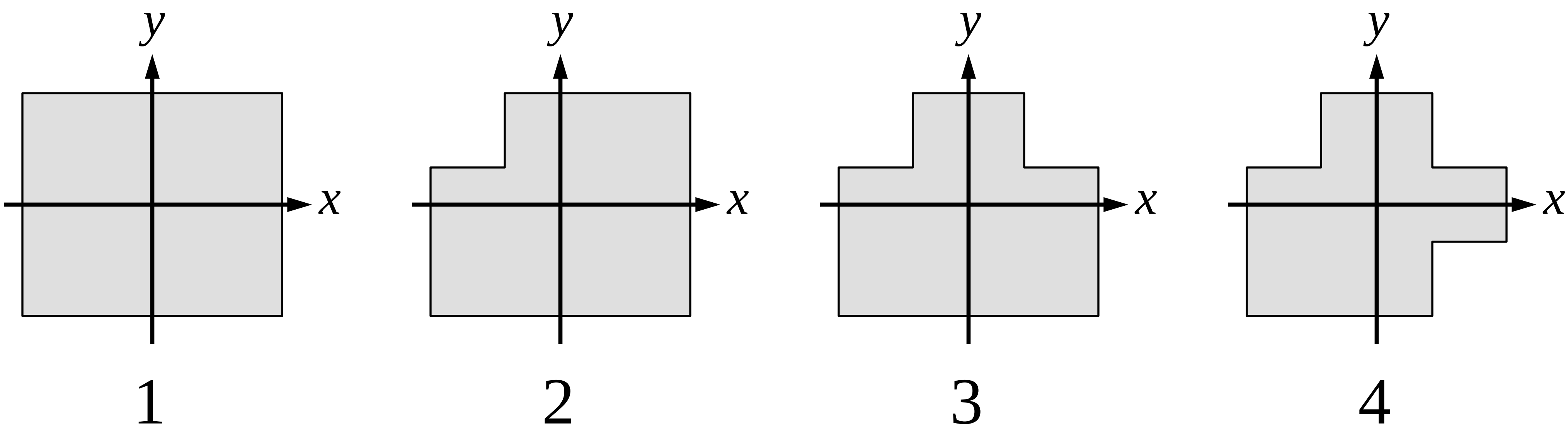
C. $W_3 > W_1 > W_2$

D. $W_3 > W_2 > W_1$



An ice dancer glides through a totally dark arena. A flashing strobe locates her at successive instants. What is the direction of the net force acting on her?





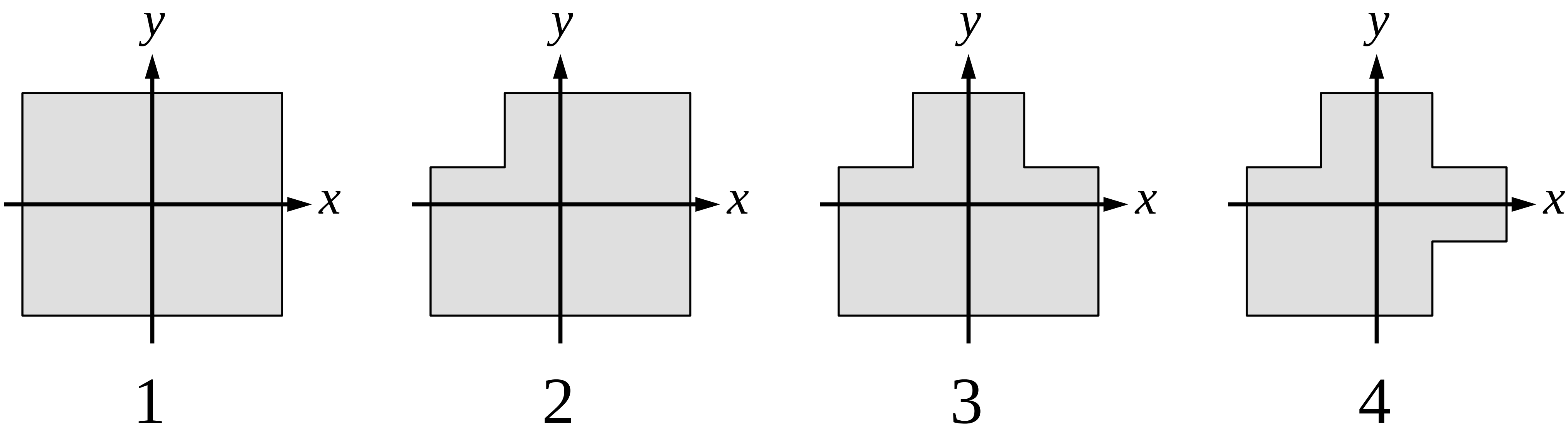
A machinist starts with a uniform sheet of steel and successively cuts out a square piece from each corner. Rank the plates according to the *x* coordinate of the center of mass.

A. $X_{\text{cm}1} > X_{\text{cm}2} > X_{\text{cm}3} > X_{\text{cm}4}$

B. $X_{\text{cm}4} > X_{\text{cm}3} > X_{\text{cm}2} > X_{\text{cm}1}$

C. $X_{\text{cm}2} > X_{\text{cm}1} = X_{\text{cm}3} > X_{\text{cm}4}$

D. None of the above



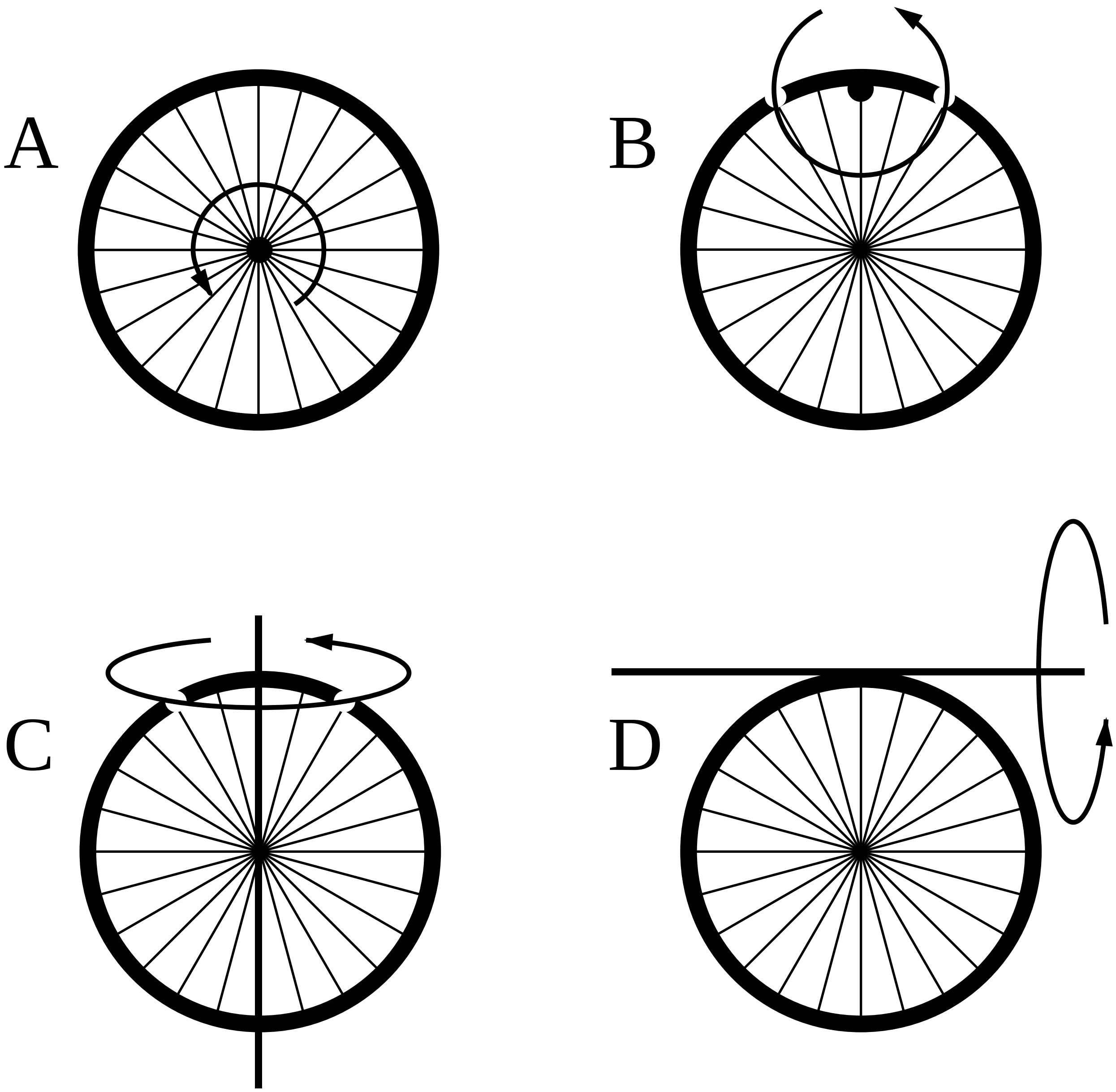
A machinist starts with a uniform sheet of steel and successively cuts out a square piece from each corner. Rank the plates according to the *y* coordinate of the center of mass.

A. $Y_{cm}1 > Y_{cm}2 > Y_{cm}3 > Y_{cm}4$

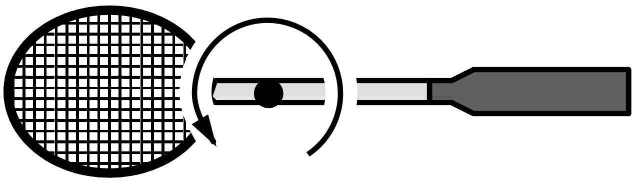
B. $Y_{cm}4 > Y_{cm}3 > Y_{cm}2 > Y_{cm}1$

C. $Y_{cm}1 > Y_{cm}2 = Y_{cm}4 > Y_{cm}3$

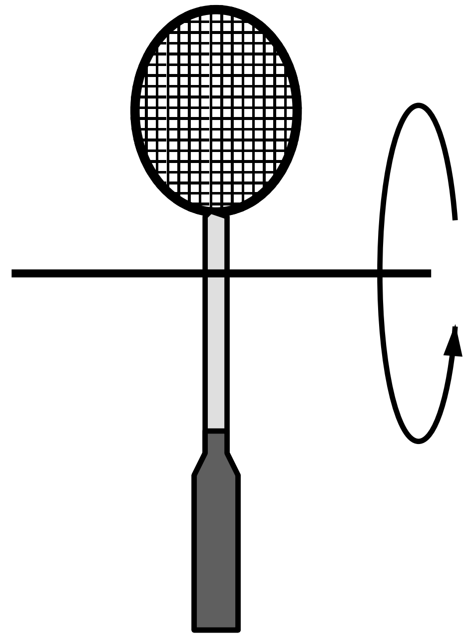
D. None of the above


A
B
C
D

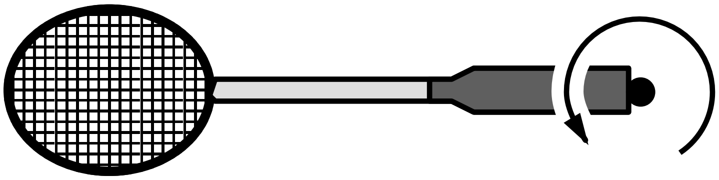
A



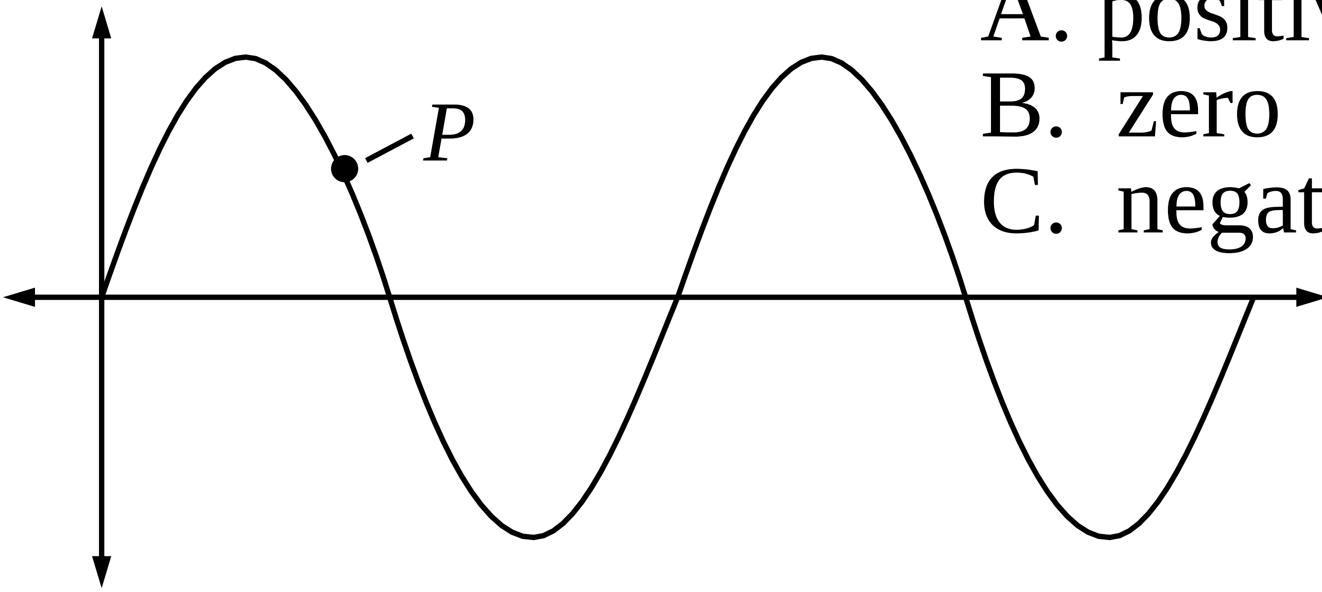
B



C



D



A. positive
B. zero
C. negative

Consider the point *P*...

If this is a graph of position vs time
1) x?
2) v?
3) a?

If this is a graph of velocity vs time
4) x?
5) v?
6) a?

If this is a graph of acceleration vs time
7) x?
8) v?
9) a?

A vector lies in the $x-y$ plane. For what orientations will both components be negative?

A. The vector lies between 90° and 180° from the $x-$axis.

B. The vector lies between 180° and 270° from the $x-$axis.

C. The vector lies between 0° and −90° from the $x-$axis.

D. None. Just like for vector magnitudes, components are always positive.

Under what circumstances would a nonzero vector lying in the $x-y$ plane have components that are equal in magnitude?

A. None of the below.

B. Only when the vector lies on the $x-$ or $y-$axes (0°, 90°, 180°, or 270°).

C. Only when the vector lies 45° from the $x-$ or $y-$axes (45°, 135°, 225°, or 315°).

D. Components of vectors are never equal (they point in different directions) and so the magnitudes can not be equal either.

An ant walks once around the perimeter of a rectangular tabletop with the dimensions 1.0 m × 2.0 m. If the ant ends up at its original position, what is its displacement and what is the distance it traveled?

A. displacement of 0 m, distance traveled 0 m

B. displacement of 0 m, distance traveled 6 m

C. displacement of 6 m, distance traveled 6 m

D. None of the above

Two vectors: $\vec{\boldsymbol{p}}$ and $\vec{\boldsymbol{q}}$ have the same

length: $|\vec{\boldsymbol{p}}| = |\vec{\boldsymbol{q}}| = 5$

how many of the below are possible lengths for the sum of the vectors?

$|\vec{\boldsymbol{p}} + \vec{\boldsymbol{q}}|$

(i) 0
(ii) 5
(iii) 10

A. 0
B. 1
C. 2
D. 3

the difference of the two vectors?

$|\vec{\boldsymbol{p}} - \vec{\boldsymbol{q}}|$

Two vectors: $\vec{\boldsymbol{p}}$ and $\vec{\boldsymbol{q}}$ have different lengths: $|\vec{\boldsymbol{p}}| > |\vec{\boldsymbol{q}}|$

how many of the below are possible lengths for the sum of the vectors?

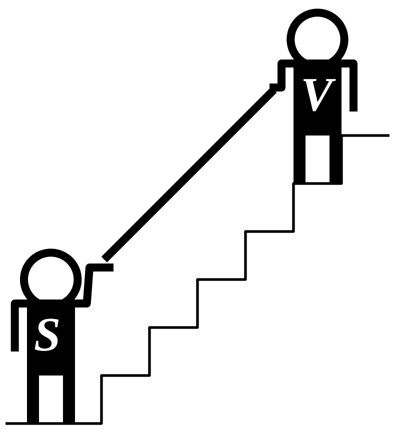
$|\vec{\boldsymbol{p}} + \vec{\boldsymbol{q}}|$

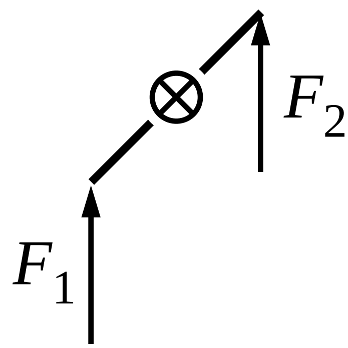
(i) 0
(ii) $|\vec{\boldsymbol{p}}| + |\vec{\boldsymbol{q}}|$
(iii) $|\vec{\boldsymbol{p}}| - |\vec{\boldsymbol{q}}|$
(iv) $|\vec{\boldsymbol{q}}| - |\vec{\boldsymbol{p}}|$
(v) $|\vec{\boldsymbol{p}}|$

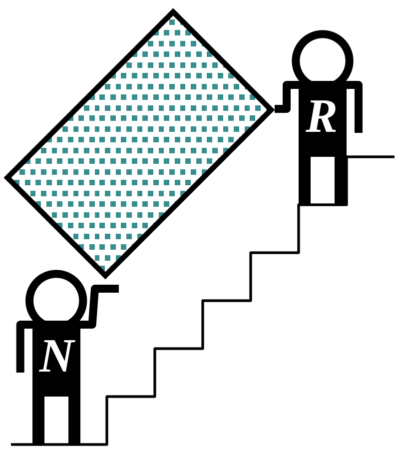
A. 0
B. 2
C. 4
D. none of above

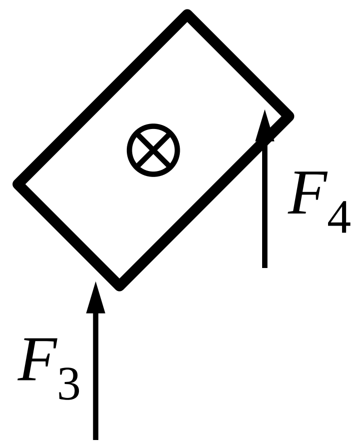
the difference of the two vectors?

$|\vec{\boldsymbol{p}} - \vec{\boldsymbol{q}}|$


S
V


F_2
F_1


R
N


F_4
F_3