Kinematics of a particle

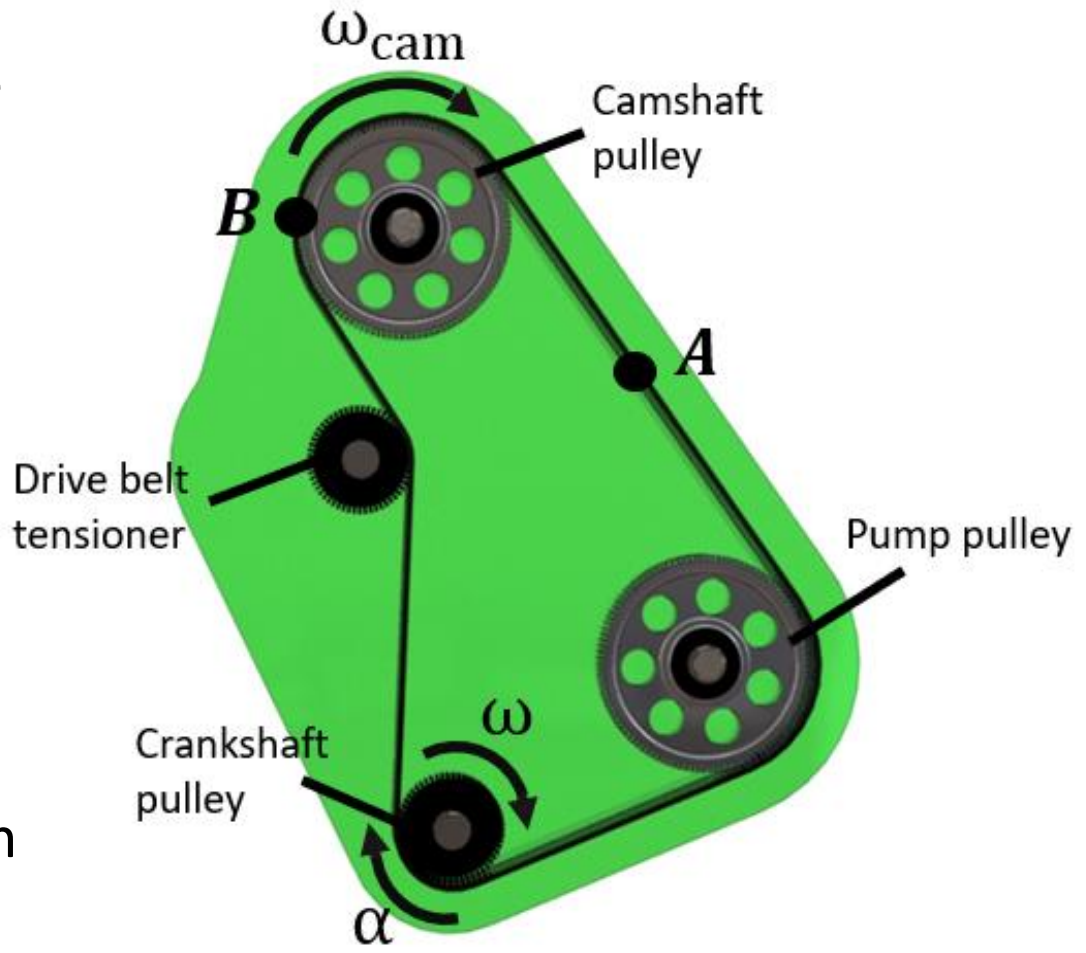
Tutorial 5

Constrained and dependent motion of particles.

Question 5.1

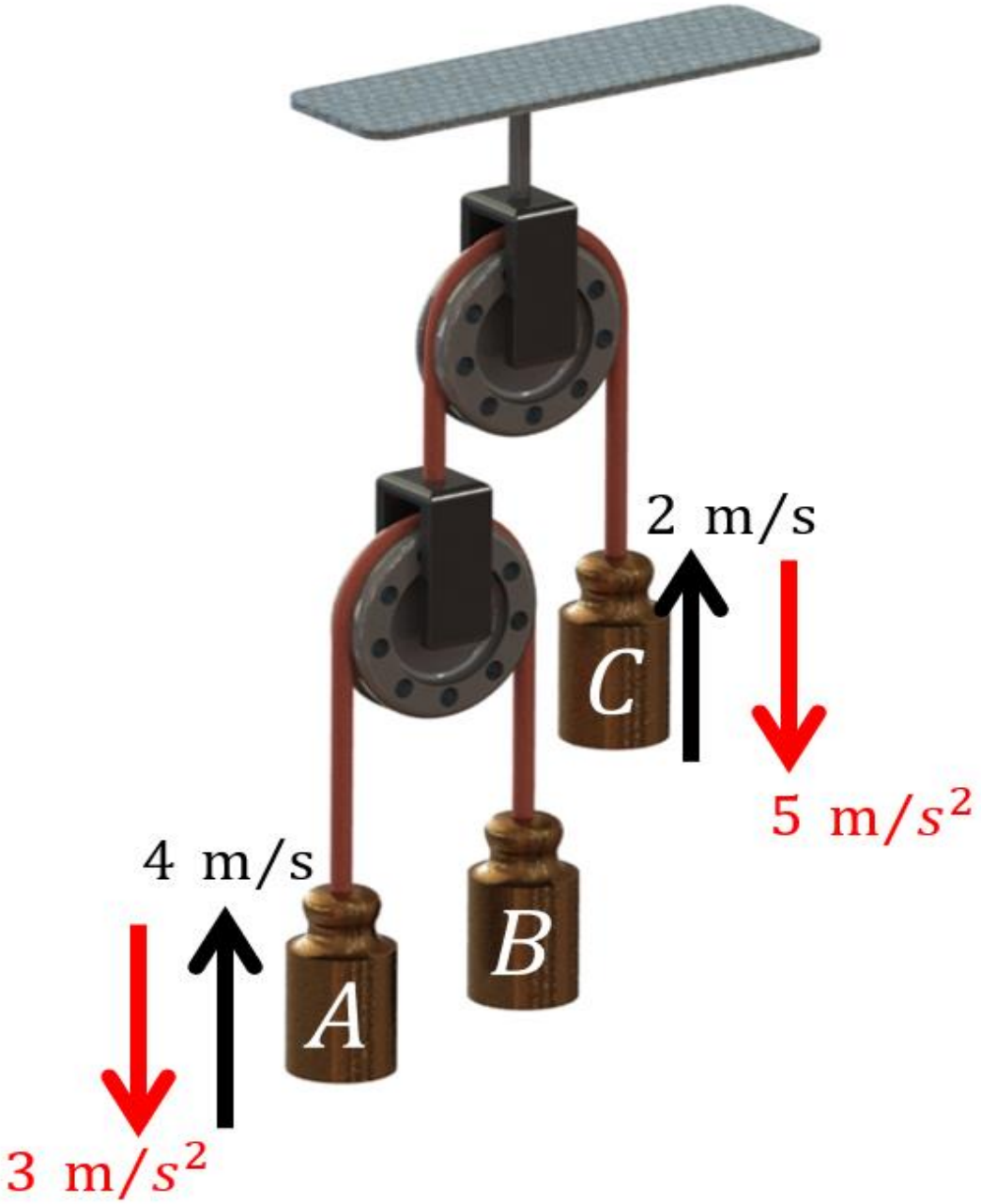
Shown in the diagram is a camshaft drive system for a four cylinder engine, where the speed of the crankshaft increases as the speed of the engine increases. At the particular instant shown the crankshaft has a clockwise angular velocity $\omega = 125\ \text{rads}/s$ and a constant clockwise angular acceleration $\alpha = 20\ \text{rads}/s^2$. The crankshaft pulley has a radius of $r_{crank} = 40\text{mm}$ and the cam shaft pulley has a radius of $r_{cam} = 80\ \text{mm}$. Assuming no slip between the belt and the pulleys determine:

a) The velocity of point ***A*** on the drive belt.
b) The acceleration of point ***A*** on the drive belt.
c) The angular velocity ω_{cam} of the camshaft pulley.
d) The magnitude and total acceleration of point ***B*** on the camshaft pulley.
e) The angular velocity ω of the crankshaft pulley after 3.5 seconds.



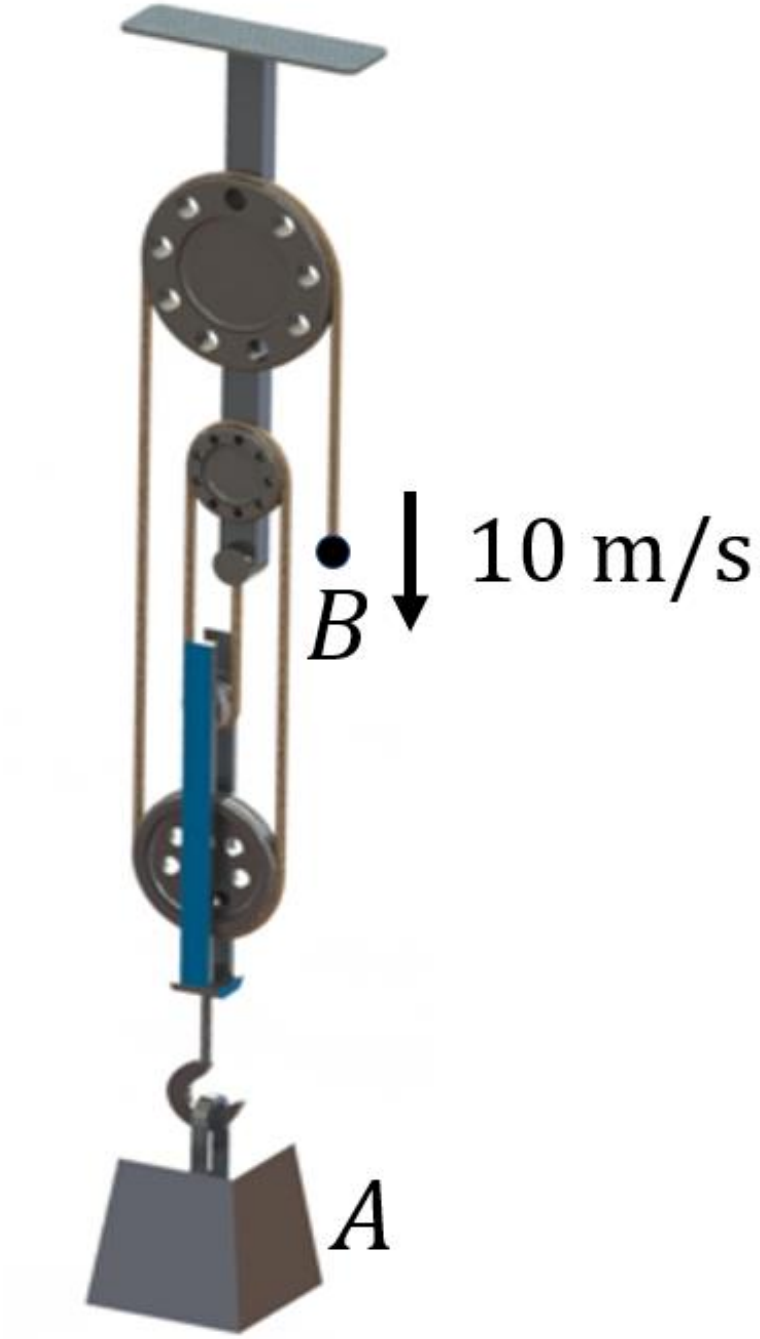
Question 5.2

What is the velocity and acceleration of weight B at the instant shown?



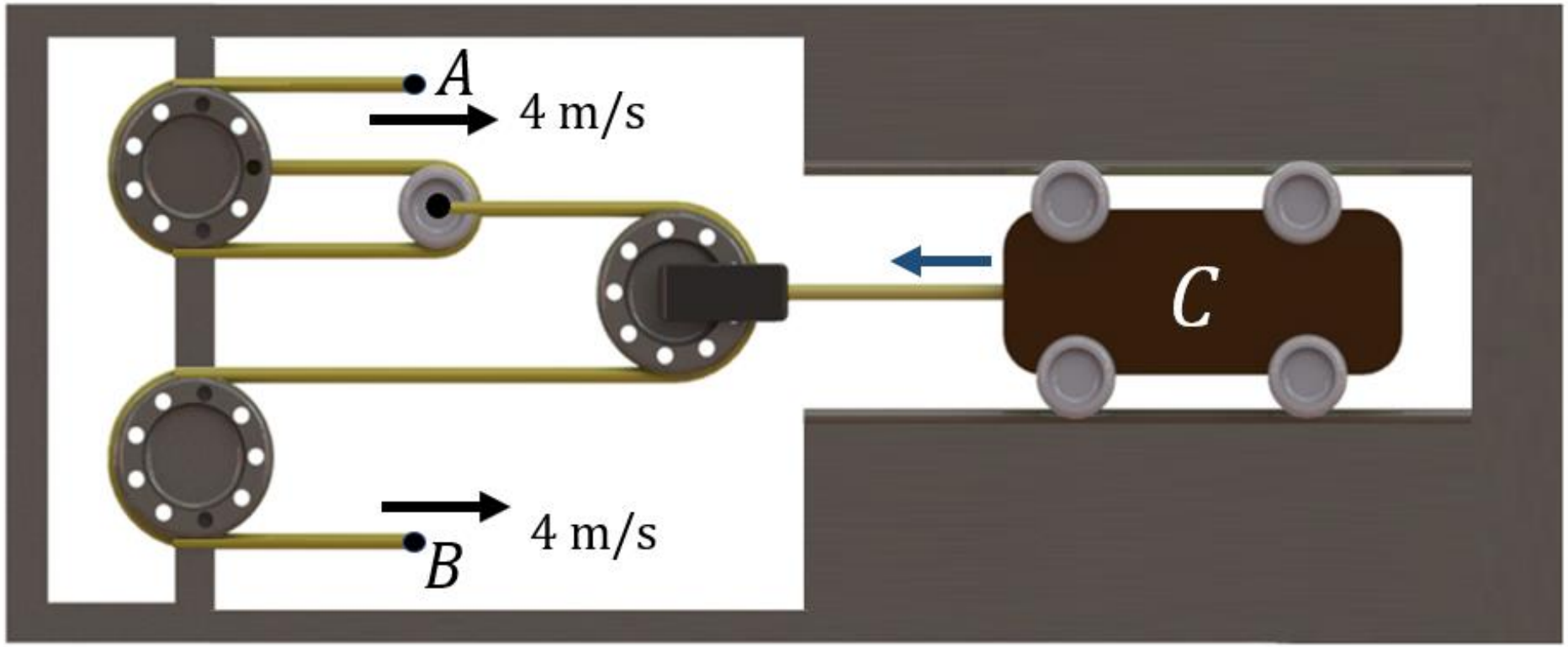
Question 5.3

What is the velocity of the weight A if the cable is pulled down at B with a constant velocity of $10\ \mathrm{m/s}$?



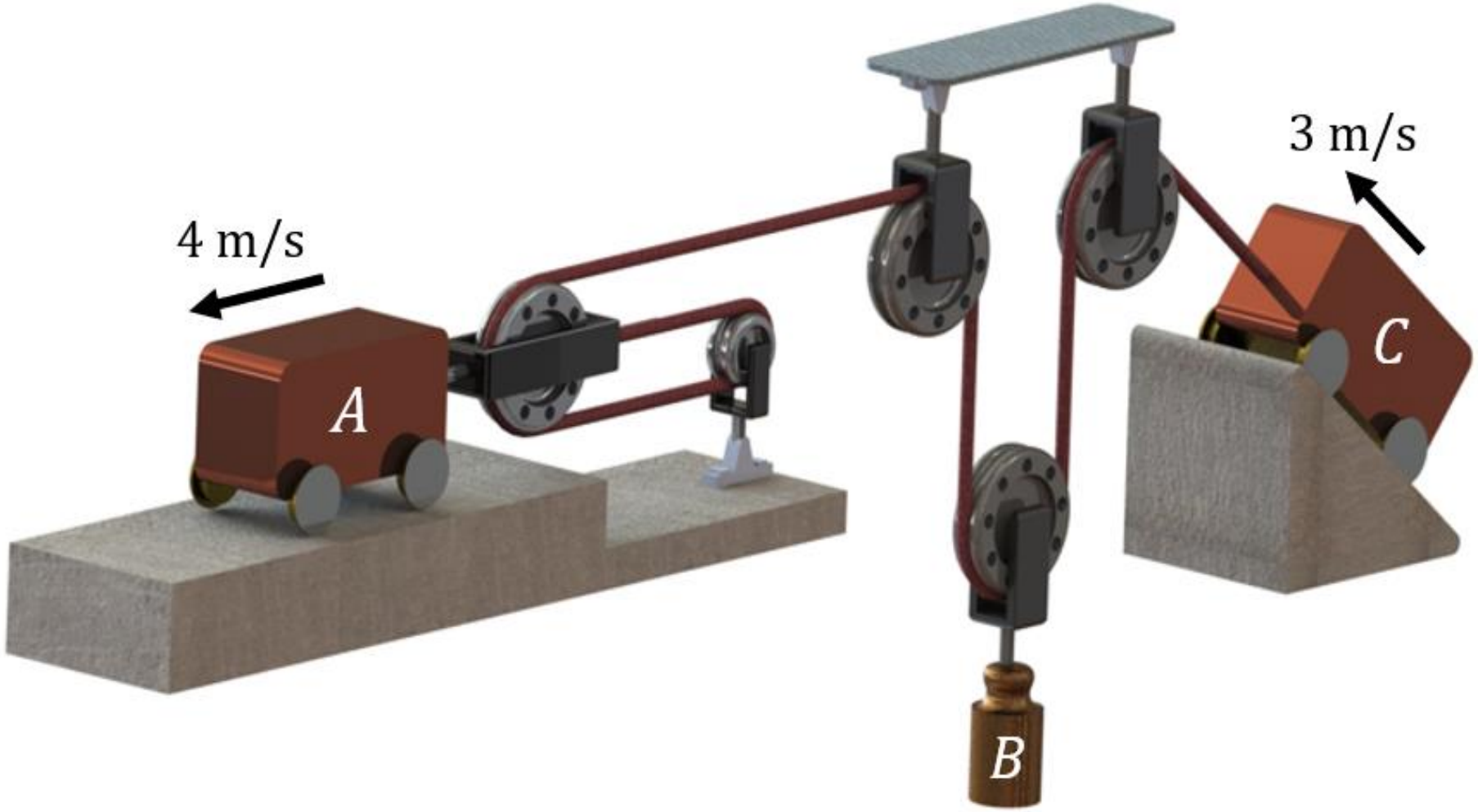
Question 5.4

The cables at point A and B are pulled to the right each with a velocity of $4\ \mathrm{m/s}$. What is the velocity of the sliding weight C?



Question 5.5

In the pulley system shown, what is the velocity of weight B?

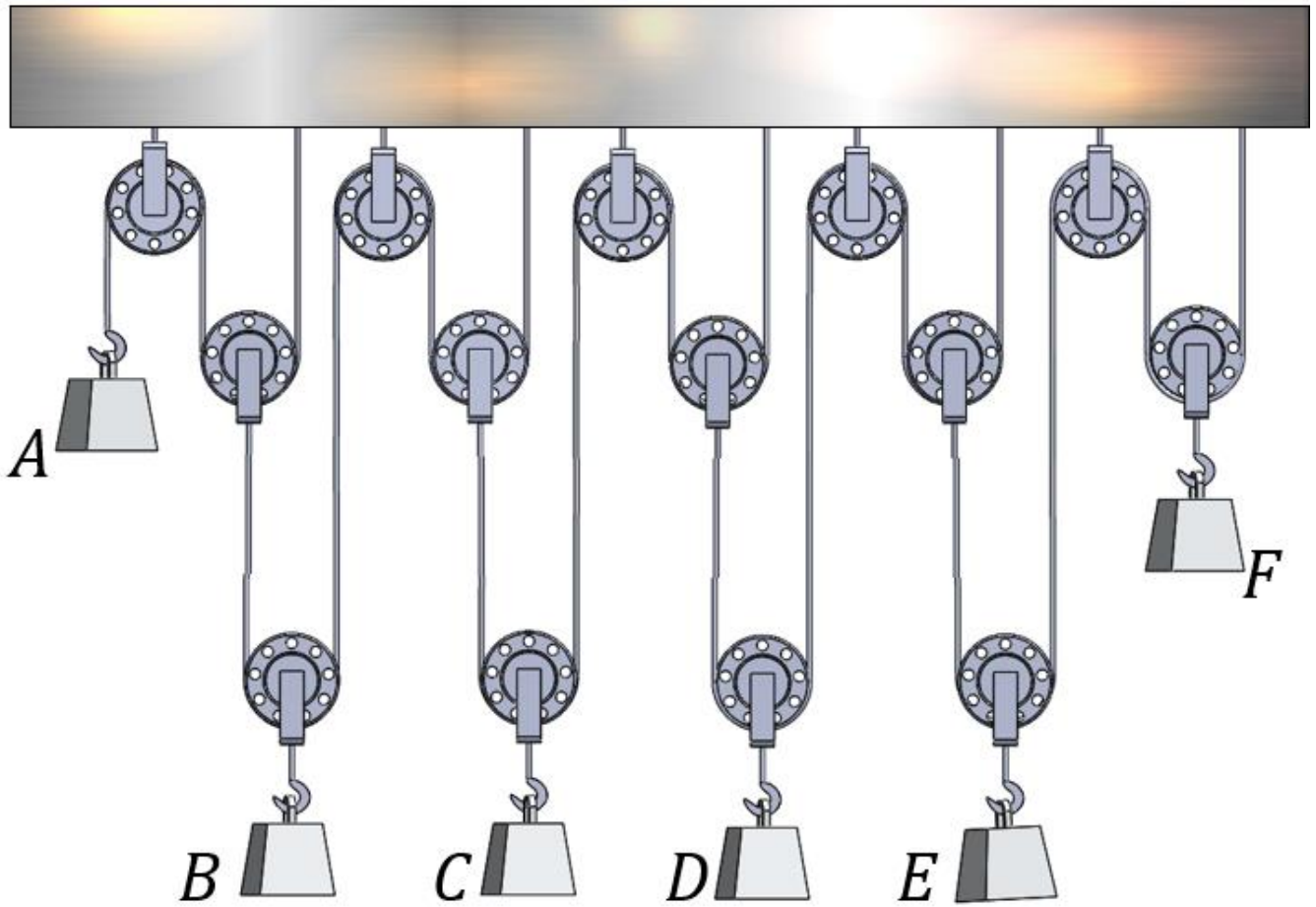


Question 5.6

Complete the following:

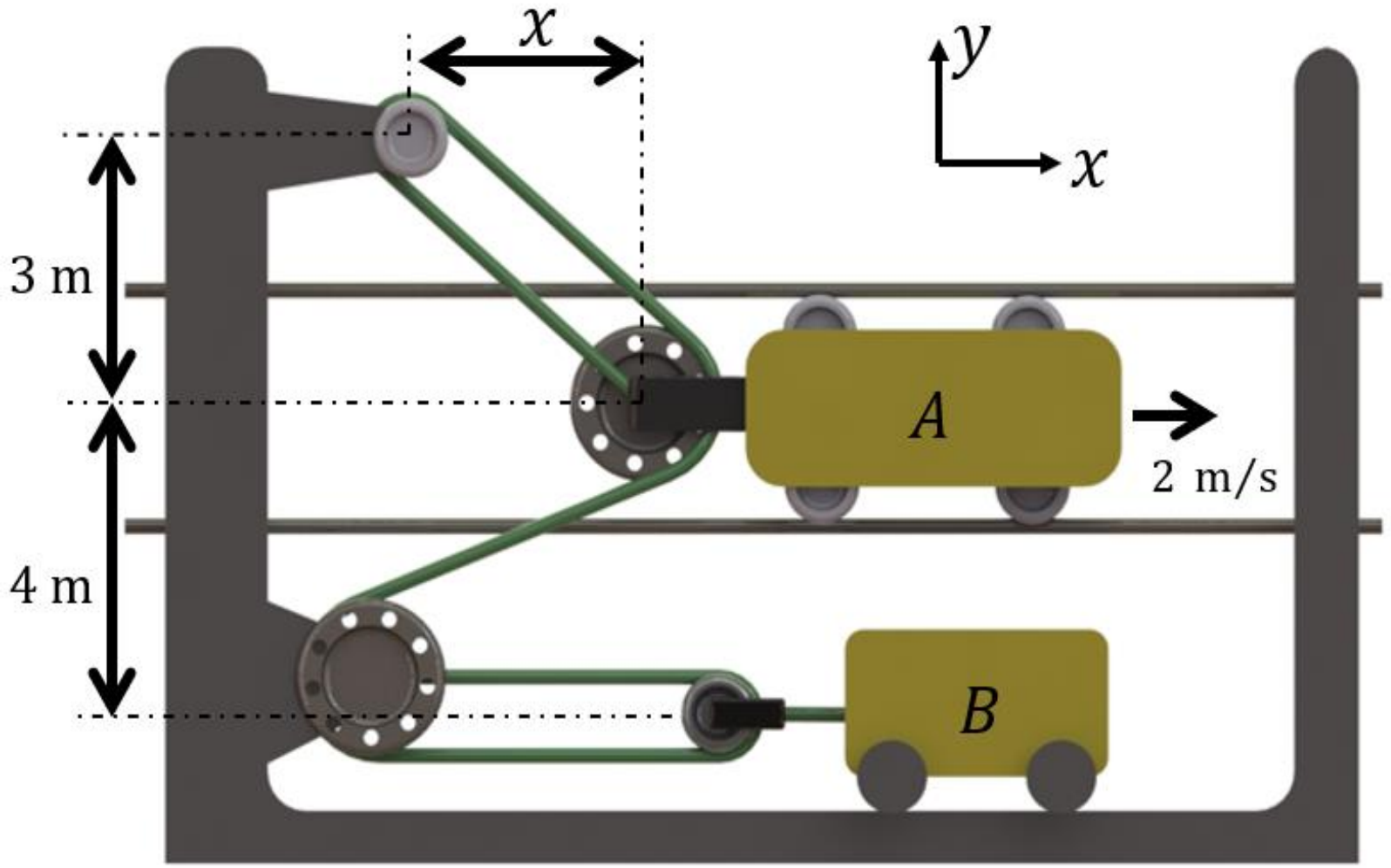
a) How many degrees of freedom does the pulley system have?

b) Find an equation which relates the velocity of all six weights.



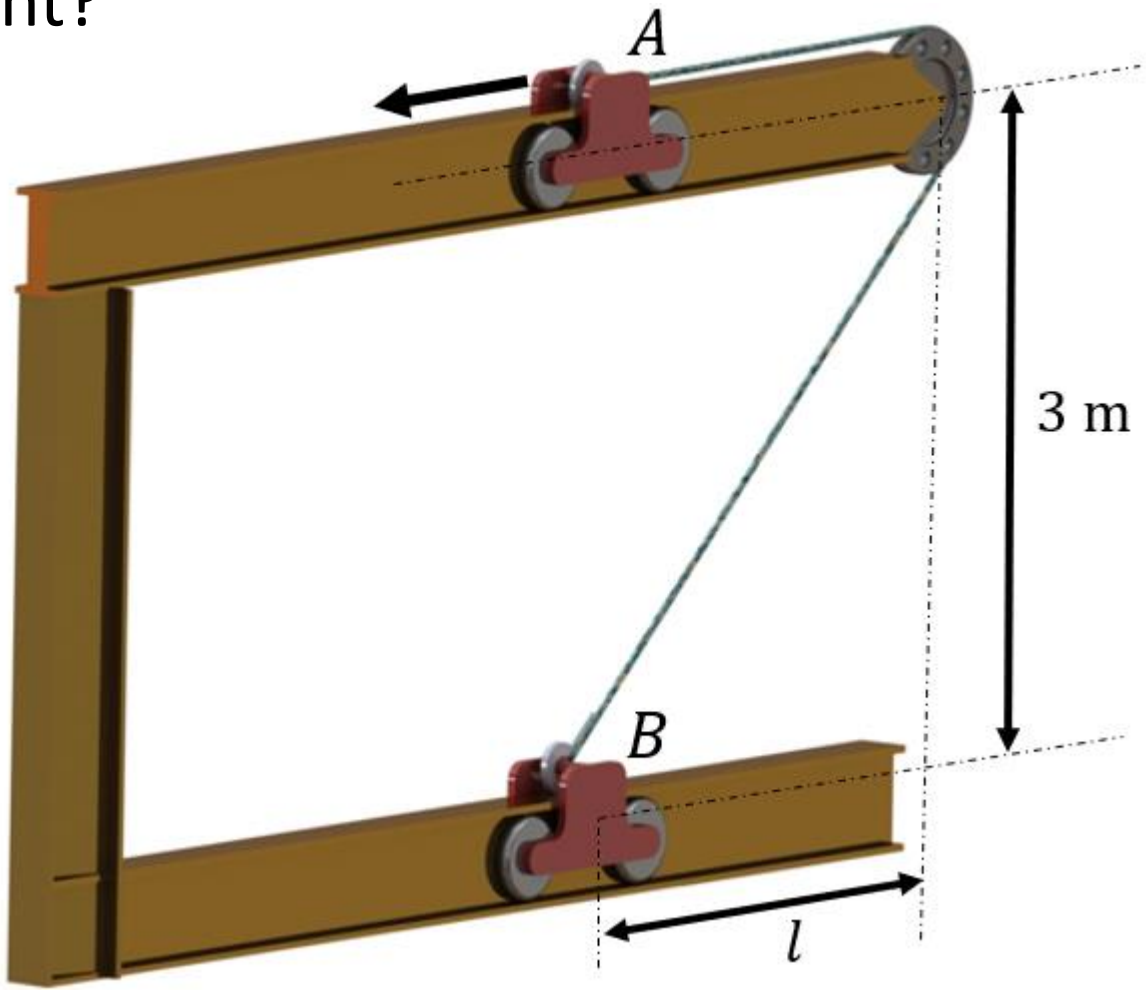
Question 5.7

In the pulley system shown what is the velocity of the sliding weight B if the sliding weight A moves to the right with a velocity of $2\ \mathrm{m/s}$ at the instant $x = 1.8\ \mathrm{m}$.



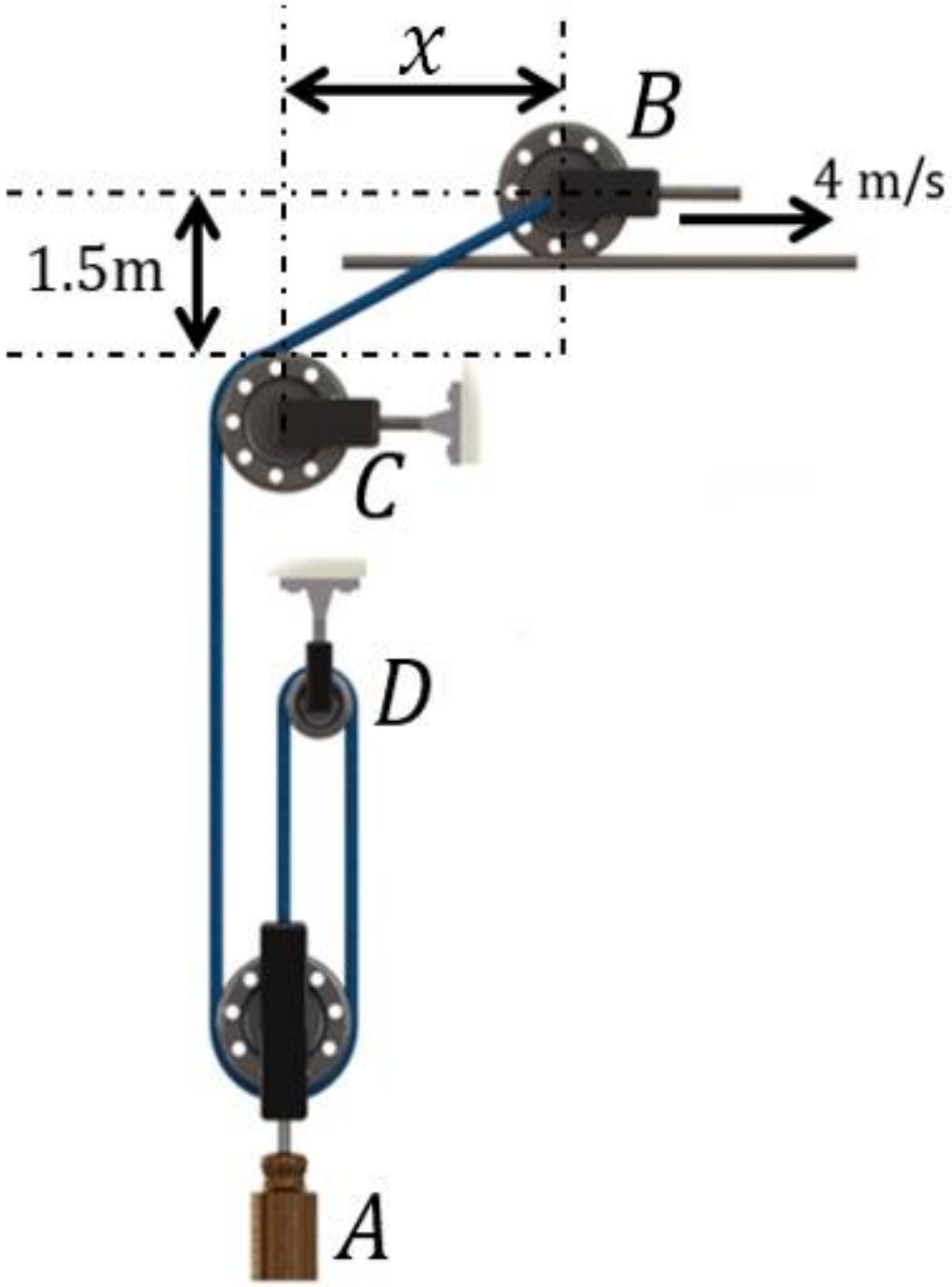
Question 5.8

The slider A moves with an acceleration of $0.75\ \mathrm{m/s^2}$. When $l = 1.75\ \mathrm{m}$ the velocity of slider A is $3\ \mathrm{m/s}$. What is the velocity and acceleration of the slider B at this instant?



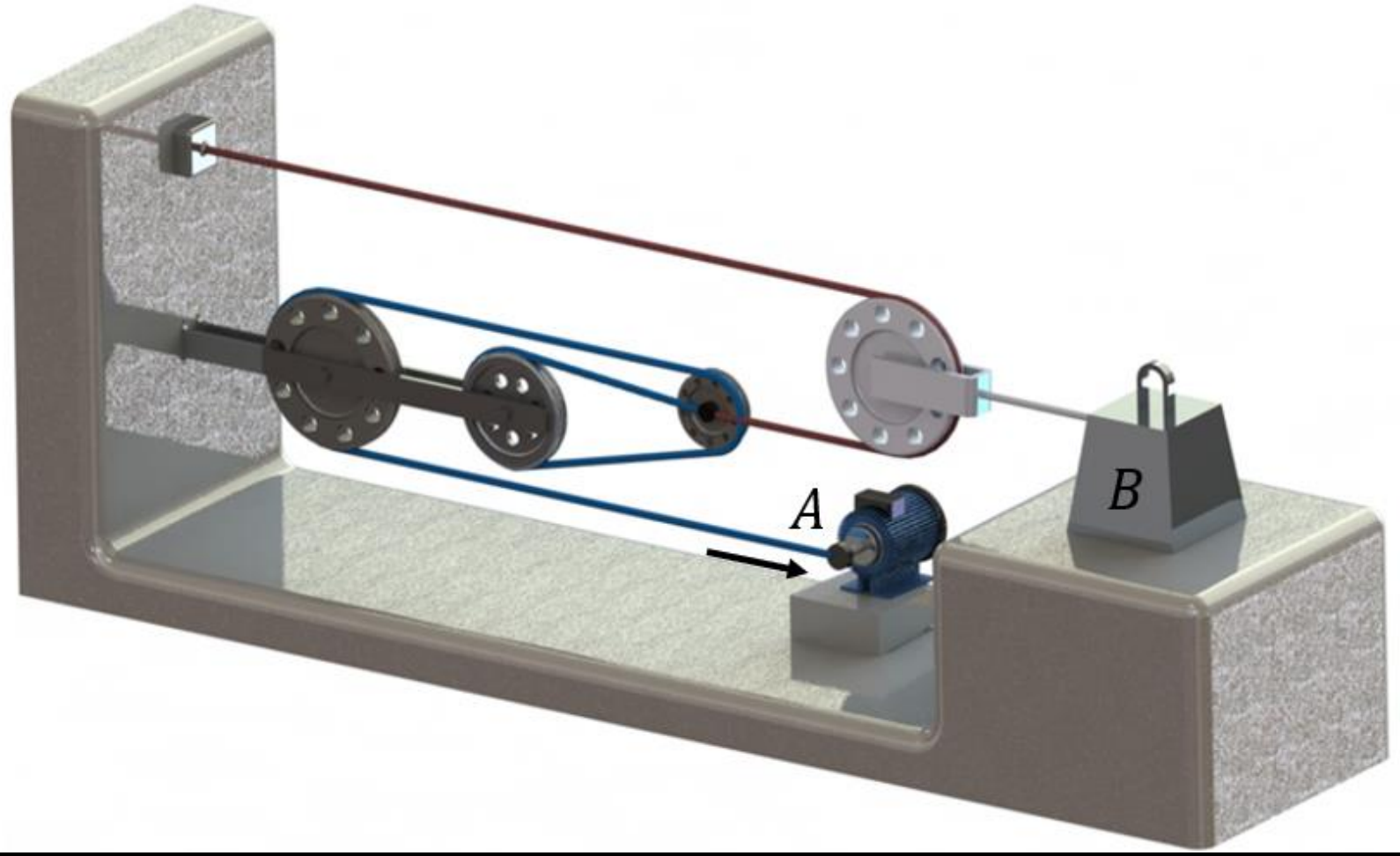
Question 5.9

The pulley at B is moving along the track with a constant velocity of $4\ \mathrm{m/s}$. Where pulleys C and D are fixed in position find the velocity and acceleration of the weight A when $x = 5\ \mathrm{m}$.



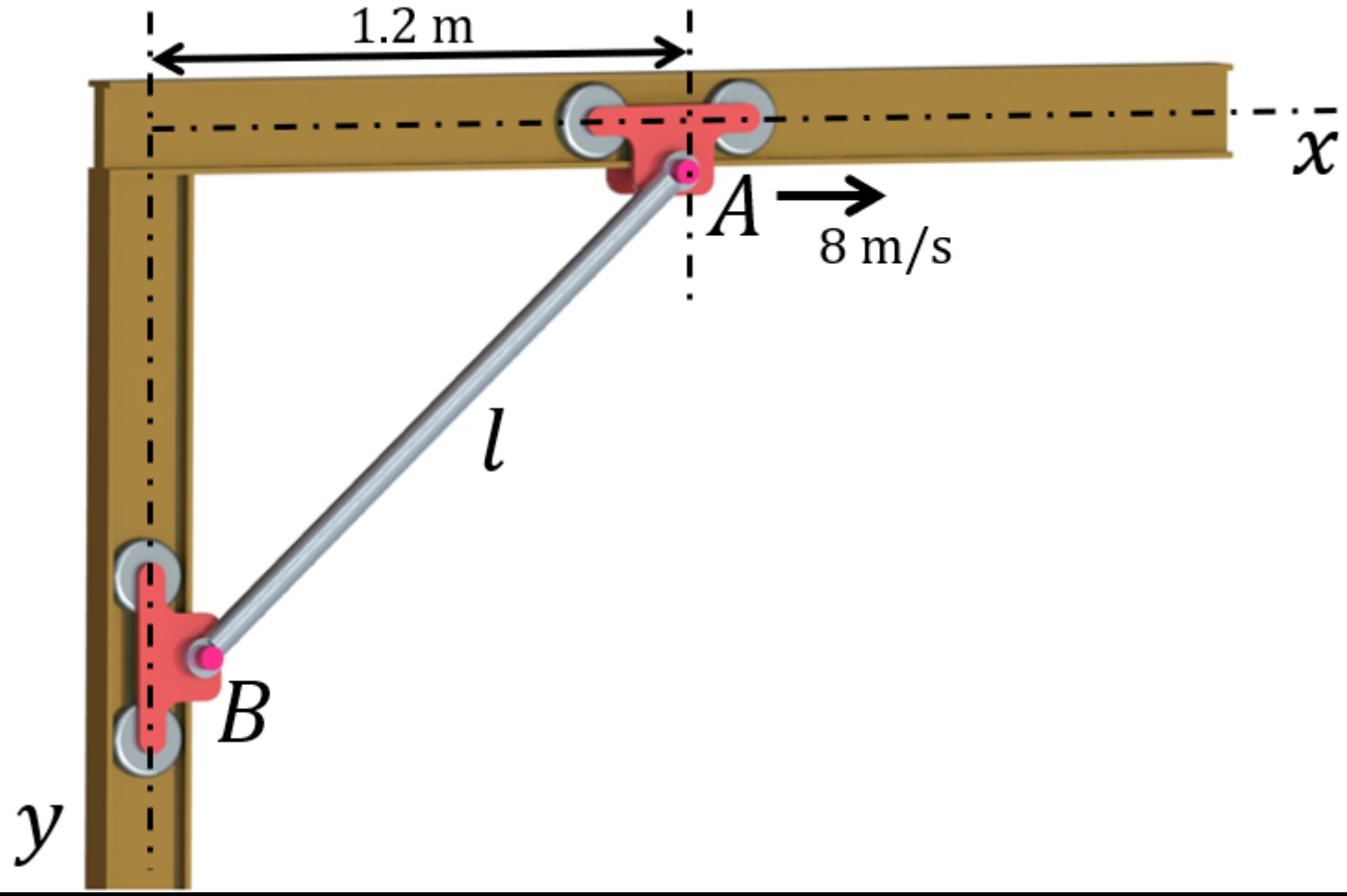
Question 5.10

The motor at A is capable of reeling in the cable at a constant rate of $2\ \mathrm{cm/s}$, what horizontal displacement d would weight B move 3 seconds after the motor is switched on?



Question 5.11

Slider A and B are connected together with a rigid aluminium rod with length $l = 1.4\ \mathrm{m}$. If the slider A has a constant velocity of $8\ \mathrm{m/s}$ find the velocity and acceleration of the slider B at the instant slider A has covered a length of $1.2\ \mathrm{m}$ along the x axis.



Question 5.12

The slider $\boldsymbol{A}$ connected to the rigid pivoting rod $\boldsymbol{OP}$ via the cable has a velocity of $2\ \mathrm{m/s}$ in the x direction. Assuming the rod connecting $\boldsymbol{OP}$ and slider $\boldsymbol{B}$ remains horizontal, determine the magnitude of velocity for slider $\boldsymbol{B}$ at the instant shown in the diagram. All necessary dimensions have been given.

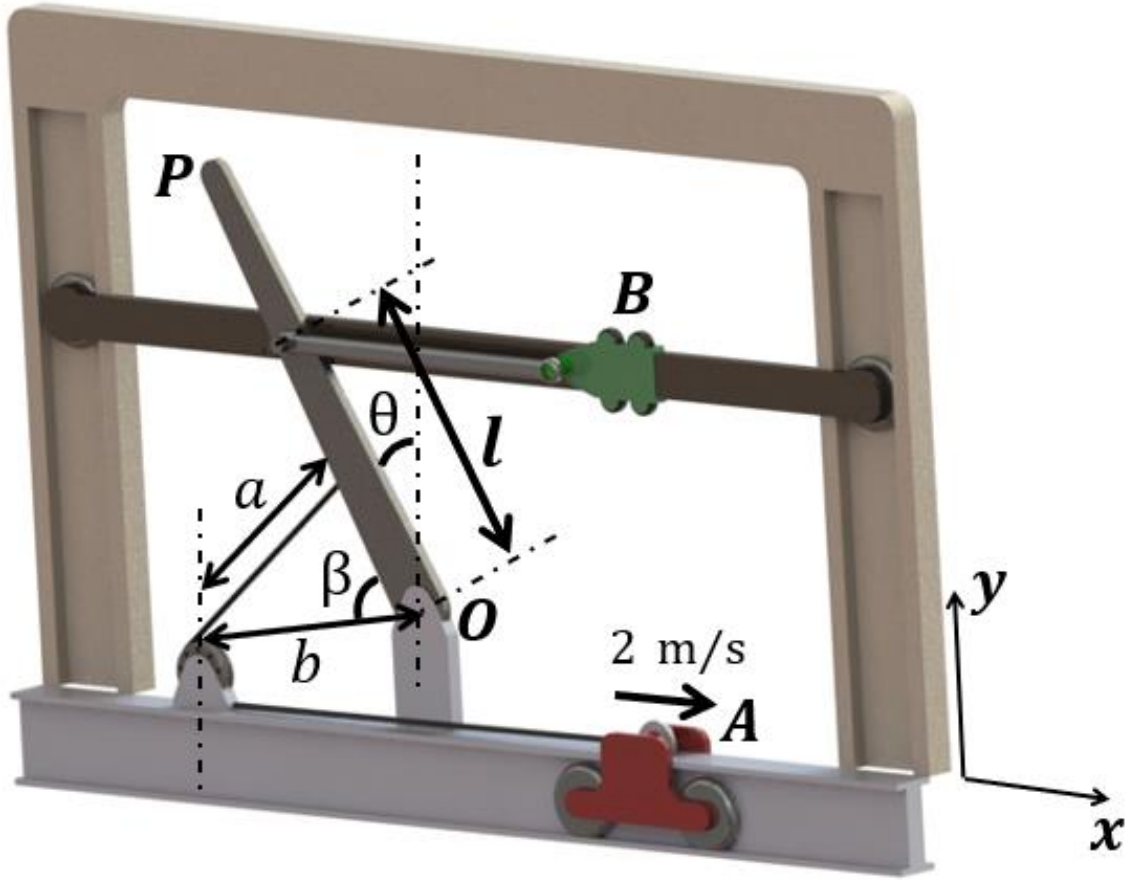
$\boldsymbol{l} = 7\mathrm{m}$

$a = 3\mathrm{m}$

$b = 4\mathrm{m}$

$\beta = 40^0$

$\theta = 30^0$



Answers are shown on the next page

Answers

Question 5.1

a) $v_A = 5\ \mathrm{m/s}$
b) $a_A = 0.\ 8\ m/s^2$
c) $\omega_{\mathrm{cam}} = 62.5\ rads/s$
d) $a = 312.5\ m/s^2$
e) $\omega\ = 195\ rads/s$

Question 5.2

$\dot{l}_B = -8\ \mathrm{m/s}$

$\ddot{l}_B = 13\ \mathrm{m/s^2}$

Question 5.3

$\dot{l}_A = -2.5\ m/s$

Question 5.4

$\dot{l}_C - 3\ m/s$

Question 5.5

$\dot{l}_B = -7.5\ m/s$

Question 5.6

a) The pulley system has 5 degrees of freedom

b) $0 = 4\dot{l}_B + \dot{l}_A + 8\dot{l}_C + 16\dot{l}_D + 32\dot{l}_E + 32\dot{l}_F$

Question 5.7

$\dot{l}_B - 1.43\ m/s$

Question 5.8

a) $\dot{l} = -5.95\ m/s$

b) $\ddot{l} = -5.33\ \mathrm{m/s^2}$

Question 5.9

a) $\dot{l}_A - 1.28 m/s$

b) $\ddot{l}_A = -0.084\ \mathrm{m/s^2}$

Question 5.10

$d = -1\ cm$

Question 5.11

a) $\dot{y} = 13.33\ m/s$

b) $\ddot{y} = -335.68\ m/s^2$

Question 5.12

$v = 3.58\ \mathrm{m/s}$