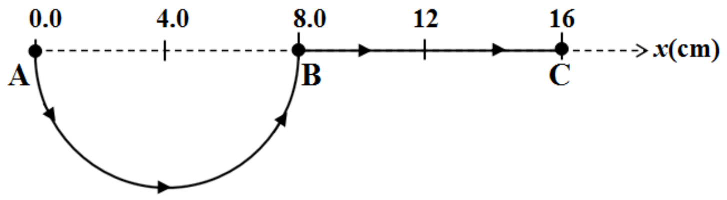
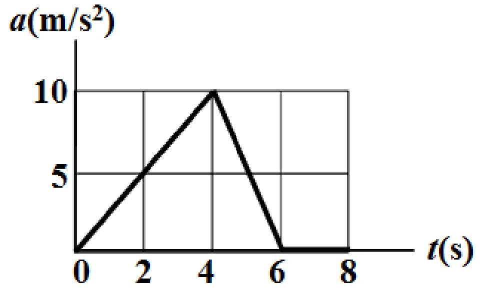
Q1.
A toy train starts moving from point A towards point B along the half-circular track shown in **Figure 1**. It continues its motion through the straight track from point B to reach point C. It then goes back and stops at point B. What is the average velocity of the train (in cm/s) if its average speed is 3.0 cm/s?



A) 0.84
B) 1.6
C) 0.69
D) 1.9
E) 1.3

Q2.
A 5.0 kg object is at rest at t = 0. It then starts moving along the x-axis. The variation of its acceleration with time is shown in **Figure 2**. What is the object's velocity (in m/s) at t = 7.0 s?



A) 30
B) 20
C) 10
D) 40
E) 0

Q3.
An automobile accelerates from rest at 2.0 m/s^2 for 20 s. It then continues moving in the same direction at a constant speed for 20 s. The automobile then decelerates at a rate of 4.0 m/s^2 until it stops. What is the total distance traveled?

A) 1400 m
B) 1200 m
C) 1000 m
D) 1600 m
E) 1800 m

Q4.
A ball is thrown vertically up from the top of a building. The ball travels up 5.0 m before it starts descending. It hits the ground with a velocity of 23 m/s. What is the height of the building?

A) 22 m
B) 17 m
C) 27 m
D) 36 m
E) 31 m

Q5.
Which one of the following statements is **always TRUE**

A) In uniform circular motion, the centripetal acceleration is perpendicular to the linear velocity of the rotating object
B) Distance is the absolute value of displacement
C) In projectile motion, the velocity of the object at the maximum height is zero
D) Acceleration is in the direction of velocity
E) In projectile motion, the acceleration of the object at the maximum height is zero

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Q6.
If $\vec{A}+\vec{B}=\vec{C}$, $\vec{A}-\vec{B}=2\vec{C}$, and $\vec{C}=3\hat{i}-3\hat{j}$, then what is the angle between $\vec{A}$ and $\vec{B}$?

A) 180°
B) 60°
C) 90°
D) 45°
E) 0°

Q7.
The torque is defined by the cross product of the position vector and the force, $\vec{\tau}=\vec{r}\times\vec{F}$. Find the torque if the position vector is $\vec{r}=2\hat{i}-2\hat{j}+3\hat{k}$ and the force is $\vec{F}=-5\hat{i}+2\hat{j}+2\hat{k}$.
(All the quantities in this problem have SI units)

A) $\vec{\tau}=-10\hat{i}-19\hat{j}-6\hat{k}$
B) $\vec{\tau}=-12\hat{i}-19\hat{j}-9\hat{k}$
C) $\vec{\tau}=+12\hat{i}-9\hat{j}-9\hat{k}$
D) $\vec{\tau}=-10\hat{i}+19\hat{j}+6\hat{k}$
E) $\vec{\tau}=-18\hat{i}-6\hat{j}-10\hat{k}$

Q8.

The position vector of an airplane is given by $\vec{r} = (3.0t\,\hat{i} - 0.2t^3\,\hat{j} + 2.0\hat{k})\,\text{m}$. Find the magnitude of the average acceleration (in m/s^2) in the period between t = 2.0 s and t =5.0 s.

A) 4.2
B) 1.6
C) 1.9
D) 3.1
E) 5.6

Q9.

A ball is thrown up from the ground with a speed of 8.0 m/s at an angle of 30° from the horizontal. What is the magnitude of the velocity of the ball when it has travelled 3.6 m horizontally?

A) 7.0 m/s
B) 6.0 m/s
C) 5.0 m/s
D) 4.0 m/s
E) 3.0 m/s

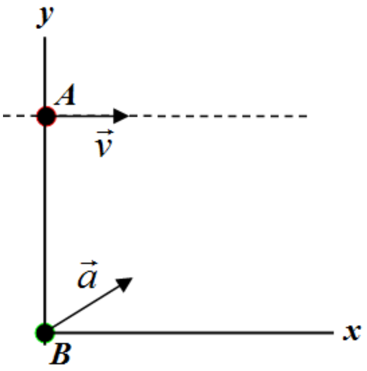
Q10.

A boat is traveling upstream in the positive direction of the x-axis at 12 km/h with respect to the flow of the river. The river is flowing at 5.0 km/h with respect to ground. What is the boat's velocity with respect to ground?

A) 7.0 km/h
B) 17 km/h
C) 12 km/h
D) 10 km/h
E) 5.0 km/h

Q11.

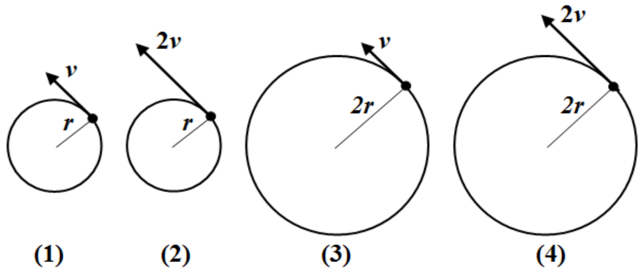
In **Figure 3**, particle *A* moves parallel to the *x*-axis, along the line y = *h*, with a constant velocity $\vec{v}$ of magnitude 2.5 m/s. At the instant particle *A* passes the *y*-axis, particle *B* leaves the origin with a zero initial velocity and a constant acceleration $\vec{a} = (0.35\hat{i} + 0.20\hat{j})$ m/s^2. The particles collide after sometime. What is the time needed for the two particles to collide?



A) 14 s
B) 22 s
C) 19 s
D) 26 s
E) 36 s

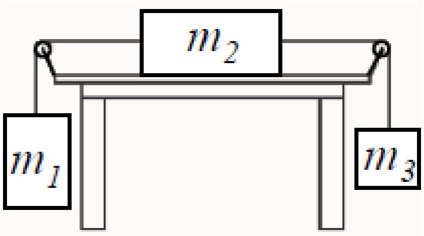
Q12.

Rank in order, from **largest to smallest**, the centripetal acceleration of the particles shown in **Figure 4**:



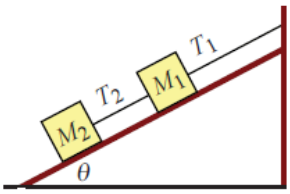
A) 2, 4, 1, 3
B) 3, 4, 1, 2
C) 4, 3, 2, 1
D) 4, 2, 3, 1
E) 1, 3, 2, 4

Q13.
The three masses (m_1 = 6.0 kg, m_2 = 10 kg and m_3 = 2.0 kg) shown in **Figure 5**, are initially held at rest. Mass m_2 lies on a frictionless, horizontal table and is connected with the other two masses by massless ropes. The ropes are passing over frictionless and massless pulleys. When released, the system starts accelerating. Find the magnitude of the acceleration (in m/s^2) of the system.



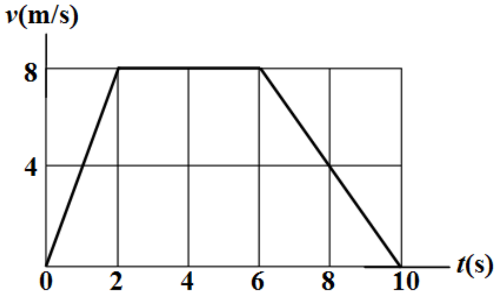
A) 2.2
B) 3.1
C) 1.7
D) 0.7
E) 3.6

Q14.
Two blocks of masses M_1 and M_2 are held at rest on a frictionless plane inclined at an angle θ by a rope attached to the wall, as shown in **Figure 6**. The tension in the rope that attaches M_1 to the wall is T_1, and the tension in the rope that attaches M_2 to M_1 is T_2. If T_1= 3T_2, then what is the mass M_2?



A) $\frac{M_1}{2}$
B) $\frac{M_1}{3}$
C) M_1
D) $2M_1$
E) $3M_1$

Q15.
Figure 7 shows the velocity vs. time graph of a 75.5 kg passenger in an elevator. What is the passenger's weight in the elevator at t = 8.00 s?



A) 589 N
B) 740 N
C) 891 N
D) 702 N
E) 563 N

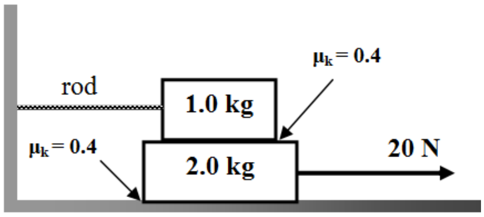
Q16.
A large car of mass 2M kg is broken down (not working). A smaller car of mass M kg pushes the larger car in a straight line and they both move at a constant speed of 4 m/s. If the force of the smaller car pushing the larger car is 2000 N, what is the magnitude of the force of the larger car on the smaller car?

A) 2000 N
B) 1000 N
C) 4000 N
D) 8000 N
E) 0

Q17.
The speed of an automobile is given by $v = a\, b\, t^2 + b\, t^3$, where the time t is in seconds and a and b are constants. The dimension of a is

A) T
B) L
C) $\frac{L}{T}$
D) $\frac{T}{L}$
E) LT

Q18.
The 1.0 kg block in **Figure 8** is tied to a wall with a massless rod and lies on top of a 2.0 kg block. The 2.0 kg block lies on a rough horizontal surface. The lower block is pulled to the right by a 20-N force. The coefficient of kinetic friction between the blocks is 0.40. The coefficient of kinetic friction between the lower block and the surface is 0.40.What is the acceleration (in m/s^2) of lower block?



A) 2.2
B) 3.1
C) 1.7
D) 0.7
E) 3.6

Q19.
The coefficient of static friction between the road and the tires of a car is 0.60. What speed will put the car on the verge of sliding as it rounds a level curve of 44 m radius?

A) 16 m/s
B) 31 m/s
C) 22 m/s
D) 11 m/s
E) 27 m/s

Q20.
A 90 g object sliding horizontally on ice is stopped in 12 m by the frictional force. Its initial velocity is 4 m/s. What is the coefficient of the kinetic friction between the object and the ice?

A) 0.07
B) 0.06
C) 0.05
D) 0.04
E) 0.03
