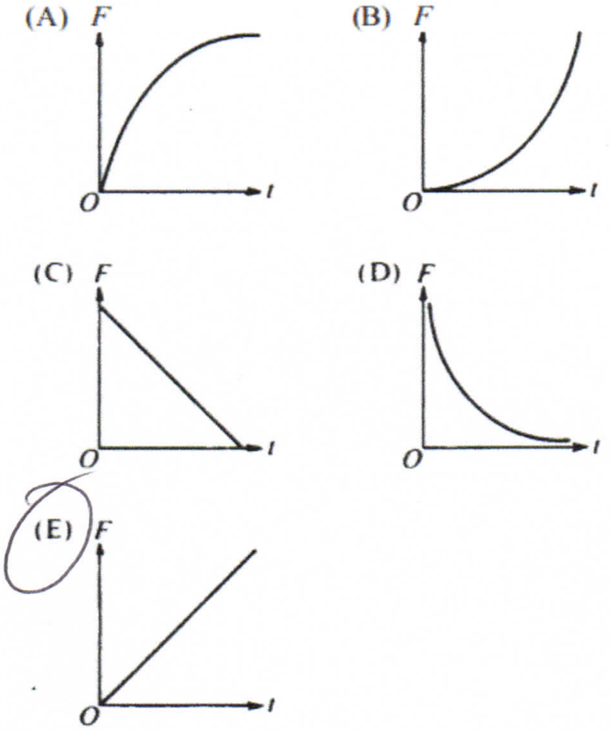
KEY

DYNAMICS PRACTICE MULTIPLE CHOICE

1984:

There should probably be a graph here, but parabola is enough.

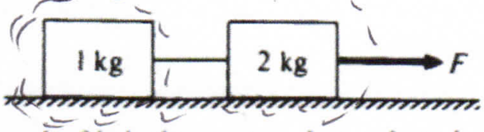
7. The parabola above is a graph of speed v as a function of time t for an object. Which of the following graphs best represents the magnitude F of the net force exerted on the object as a function of time t ?



If speed is parabola than acceleration is linear. Since $F = ma$, force is linear too.

$(1kg)\left(\frac{F}{3}\right) = F_t$

$F_t = F/3$



$F = (3kg)(a)$

$a = F/3$

9. When the frictionless system shown above is accelerated by an applied force of magnitude F, the tension in the string between the blocks is (A) 2 F (B) F (C) (2/3)F (D) 0.5F (E) (1/3)F

20. The mass of Planet X is one-tenth that of the Earth, and its diameter is one-half that of the Earth. The acceleration ~~due to gravity~~ at the surface of Planet X is most nearly
(A) 2m/s² (B) 4m/s² (C) 5m/s² (D) 7 m/s² (E) 10 m/s²

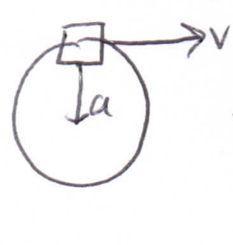
$\frac{Gm_1m_2}{r^2}$ $\frac{G(\frac{1}{10}m_1)(m_2)}{(\frac{1}{2}r)^2}$ $\frac{\frac{1}{10}}{\frac{1}{4}} = \frac{2}{5}g$ $= (\frac{2}{5})(10) = \boxed{4}$

30. A racing car is moving around the circular track of radius 300 meters shown above. At the instant when the car's velocity is directed due east, its acceleration is directed due south and has a magnitude of 3 meters per second squared. When viewed from above, the car is moving
(A) clockwise at 30 m/s (B) clockwise at 10 m/ s (C) counterclockwise at 30 m/s
(D) counterclockwise at 10 m/s (E) with constant velocity

$a_c = \frac{v^2}{r}$

$3 m/s^2 = \frac{v^2}{300}$

$v = 30 m/s$

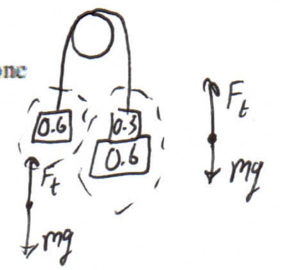


1993:

Newton's third law

5. If F_1 is the magnitude of the force exerted by the Earth on a satellite in orbit about the Earth and F_2 is the magnitude of the force exerted by the satellite on the Earth, then which of the following is true?
(A) F_1 is much greater than F_2. (B) F_1 is slightly greater than F_2.
(C) F_1 is equal to F_2. (D) F_2 is slightly greater than F_1 (E) F_2 is much greater than F_1

9 Two 0.60-kilogram objects are connected by a thread that passes over a light, frictionless pulley, as shown above. The objects are initially held at rest. If a third object with a mass of 0.30 kilogram is added on top of one of the 0.60-kilogram objects as shown and the objects are released, the magnitude of the acceleration of the 0.30-kilogram object is most nearly
(A) 10.0 m/s² (B) 6.0 m/s² (C) 3.0 m/s² (D) 2.0 m/s² (E) 1.0 m/s²



$(0.6)(a) = F_t - (0.6)(g)$
$(0.9)(a) = (0.9)(g) - F_t$
$1.5a = 0.3g$
$a = 2 \text{ m/s}$

22. A newly discovered planet has twice the mass of the Earth, but the acceleration due to gravity on the new planet's surface is exactly the same as the acceleration due to gravity on the Earth's surface. The radius of the new planet in terms of the radius R of Earth is

(A) ½R (B) $\frac{\sqrt{2}}{2}$R (C) $\sqrt{2}$ R (D) 2R (E) 4R

$\frac{G(2m_1)(m_2)}{x^2 r^2}$ $\frac{2}{x^2} = 1$ $\boxed{x = \sqrt{2}}$

1998:

4. The position of a toy locomotive moving on a straight track along the x-axis is given by the equation $x = t^3 - 6t^2 + 9t$, where x is in meters and t is in seconds. The net force on the locomotive is equal to zero when t is equal to
(A) zero (B) 2 s (C) 3 s (D) 4 s (E) 5 s

$x' = 3t^2 - 12t + 9$
$x'' = a(t) = 6t - 12$
$6t - 12 = 0$
$t = 2$

Questions 7-8 refer to a ball that is tossed straight up from the surface of a small, spherical asteroid with no atmosphere. The ball rises to a height equal to the asteroid's radius and then falls straight down toward the surface of the asteroid.

7. What forces, if any, act on the ball while it is on the way up?

r is in numerator

(A) Only a decreasing gravitational force that acts downward
(B) Only an increasing gravitational force that acts downward
(C) Only a constant gravitational force that acts downward
(D) Both a constant gravitational force that acts downward and a decreasing force that acts upward
(E) No forces act on the ball.

8. The acceleration of the ball at the top of its path is
(A) at its maximum value for the ball's flight
(B) equal to the acceleration at the surface of the asteroid
(C) equal to one-half the acceleration at the surface of the asteroid
(D) equal to one-fourth the acceleration at the surface of the asteroid
(E) zero

$\frac{1}{(2r)^2} = \boxed{\frac{1}{4}}$

11. A satellite of mass M moves in a circular orbit of radius R with constant speed v. True statements about this satellite include which of the following?
I. Its angular speed is v/R.
II. Its tangential acceleration is zero.
III. The magnitude of its centripetal acceleration is constant.

FACTS

$r\omega = v$ $\omega = \frac{v}{r}$

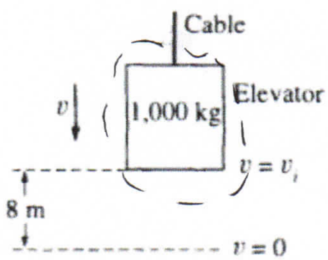
(A) I only (B) II only (C) I and III only (D) II and III only (E) I, II, and III

Top View

A spring has a force constant of 100 N/m and an unstretched length of 0.07 m. One end is attached to a post that is free to rotate in the center of a smooth table, as shown in the top view above. The other end is attached to a 1 kg disc moving in uniform circular motion on the table, which stretches the spring by 0.03 m. Friction is negligible.

14. What is the centripetal force on the disc? (A) 0.3 N (B) 3N (C) 10 N (D) 300 N (E) 1,000 N

$kx = (0.03m)(100 N/m) = 3N$



11,000N

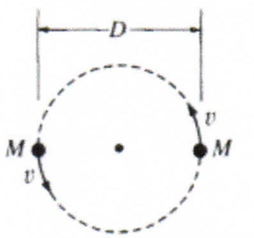
1000g

$(1000kg)(a) = 1000N$

$a = -1\ m/s^2$

$0 = V_0^2 + 2(-1)(-8)$ $V_0 = 4$

19. A descending elevator of mass 1,000 kg is uniformly decelerated to rest over a distance of 8 m by a cable in which the tension is 11,000 N. The speed v_i of the elevator at the beginning of the 8 m descent is most nearly
(A) 4 m/s (B) 10 m/s (C) 13 m/s (D) 16 m/s (E) 21 m/s



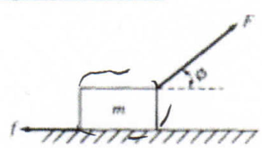
20. Two identical stars, a fixed distance D apart, revolve in a circle about their mutual center of mass, as shown above. Each star has mass M and speed v. G is the universal gravitational constant. Which of the following is a correct relationship among these quantities?
(A) $v^2 = GM/D$ (B) $v^2 = GM/2D$ (C) $v^2 = GM/D^2$ (D) $v^2 = MGD$ (E) $v^2 = 2GM^2/D$

$\frac{Mv^2}{D/2} = \frac{GMM}{D^2}$

$GM(\frac{D}{2}) = v^2 D^2$

$v^2 = \frac{GM}{2D}$

Questions 21-22



$mg = F_N + F\sin\theta$

A block of mass m is accelerated across a rough surface by a force of magnitude F that is exerted at an angle φ with the horizontal, as shown above. The frictional force on the block exerted by the surface has magnitude f.

21. What is the acceleration of the block?
(A) F/m (B) $F\cos\phi/m$ (C) $(F-f)/m$ (D) $(F\cos\phi-f)/m$ (E) $(F\sin\phi-mg)/m$

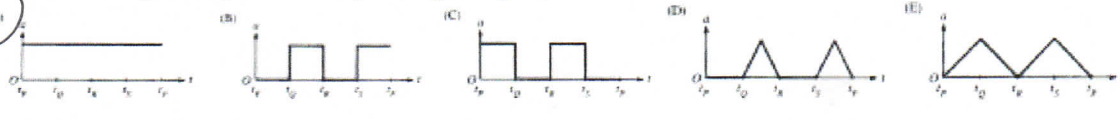
$ma = F\cos\phi - f$ $a = \frac{F\cos\phi - f}{m}$

22. What is the coefficient of friction between the block and the surface?
(A) f/mg (B) mg/f (C) $(mg-F\cos\phi)/f$ (D) $f/(mg-F\cos\phi)$ (E) $f/(mg-F\sin\phi)$

$f = \mu F_N$ $\mu = f/F_N$ $F_N = mg - F\sin\theta$

25. A figure of a dancer on a music box moves counterclockwise at constant speed around the path shown above. The path is such that the lengths of its segments, *PQ*, *QR*, *RS*, and *SP*, are equal. Arcs *QR* and *SP* are semicircles. Which of the following best represents the magnitude of the dancer's acceleration as a function of time t during one trip around the path, beginning at point *P*?

accel is constant in circle

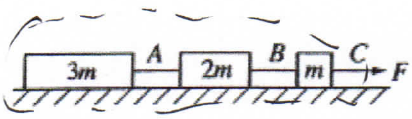


34. An object is released from rest at time t = 0 and falls through the air, which exerts a resistive force such that the acceleration a of the object is given by a = g - bv, where v is the object's speed and b is a constant. If limiting cases for large and small values of t are considered, which of the following is a possible expression for the speed of the object as an explicit function of time?

(A) $v = g(1 - e^{-bt})/b$ (B) $V = (ge^{bt})/b$ (C) $v = gt - bt^2$ (D) $v = (g + a)t/b$ (E) $v = v_0 + gt$, $v_0 \neq 0$

at one point, object will reach terminal (constant) velocity, Choice A is the only one that approaches 0

2004:



$F = (6m)(a)$

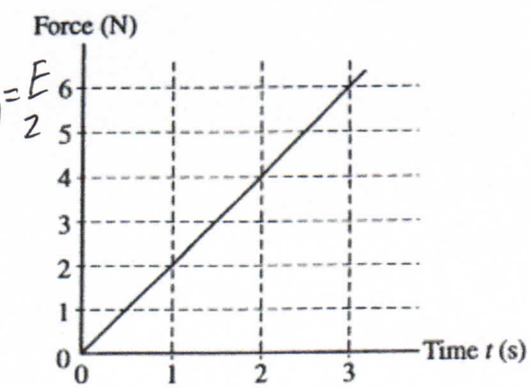
$a = F/6m$

$F_{tA} = (3m)\left(\frac{F}{6m}\right) = \frac{F}{2}$

4. Three blocks of masses $3m$, $2m$, and m are connected to strings *A*, *B*, and *C* as shown above. The blocks are pulled along a rough surface by a force of magnitude *F* exerted by string *C*. The coefficient of friction between each block and the surface is the same. Which string must be the strongest in order not to break?

(A) *A* — most mass, most force.
(B) *B*
(C) *C*
(D) They must all be the same strength.
(E) It is impossible to determine without knowing the coefficient of friction.

Questions 5-6



A block of mass 3 kg, initially at rest, is pulled along a frictionless, horizontal surface with a force shown as a function of time t by the graph above.

5. The acceleration of the block at t = 2 s is

(A) 3/4 m/s²
(B) 4/3 m/s²
(C) 2 m/s²
(D) 8 m/s²
(E) 12 m/s²

$4N = (3kg)(a)$

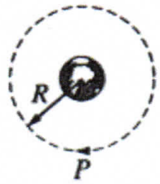
6. The speed of the block at t = 2 s is

(A) 4/3 m/s
(B) ~~8/3 m/s~~
(C) 4 m/s
(D) 8 m/s
(E) 24 m/s

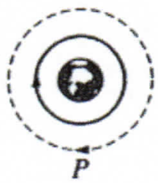
$\int F\,dt = \Delta P = 4\ kg\,m/s$

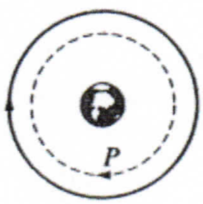
$(3kg)(v) = 4$

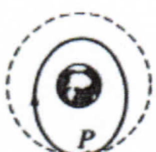
$v = 4/3$

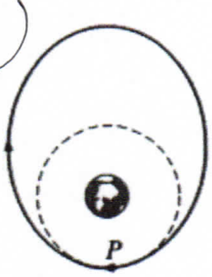


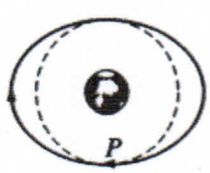
14. A spacecraft orbits Earth in a circular orbit of radius R, as shown above. When the spacecraft is at position P shown, a short burst of the ship's engines results in a small increase in its speed. The new orbit is best shown by the solid curve in which of the following diagrams?

(A)


(B)


(C)


(D)


(E)


Not quite sure how to explain:

20. Two blocks of masses M and m, with $M > m$, are connected by a light string. The string passes over a frictionless pulley of negligible mass so that the blocks hang vertically. The blocks are then released from rest. What is the acceleration of the block of mass M ?

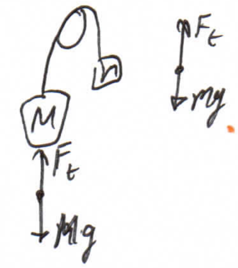
(A) g

(B) $\frac{M-m}{M}g$

(C) $\frac{M+m}{M}g$

(D) $\frac{M+m}{M-m}g$

(E) $\frac{M-m}{M+m}g$

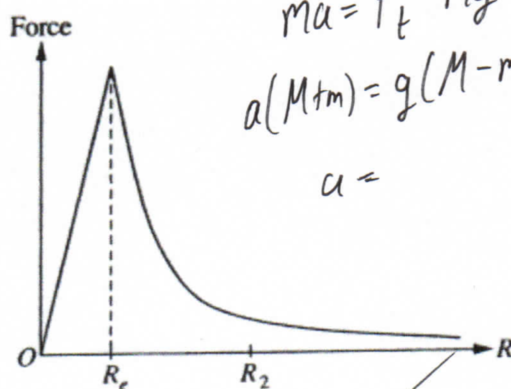


$Ma = Mg - F_t$

$ma = F_t - mg$

$a(M+m) = g(M-m)$

$a =$



27. The graph above shows the force of gravity on a small mass as a function of its distance R from the center of the Earth of radius R_e, if the Earth is assumed to have a uniform density. The work done by the force of gravity when the small mass approaches Earth from far away and is placed into a circular orbit of radius R_2 is best represented by the area under the curve between

(A) $R = 0$ and $R = R_e$
(B) $R = 0$ and $R = R_2$
(C) $R = R_e$ and $R = R_2$
(D) $R = R_e$ and $R = \infty$
(E) $R = R_2$ and $R = \infty$

Not this unit

32. A student is testing the kinematic equations for uniformly accelerated motion by measuring the time it takes for light-weight plastic balls to fall to the floor from a height of 3 m in the lab. The student predicts the time to fall using g as $9.80\ \text{m/s}^2$ but finds the measured time to be 35% greater. Which of the following is the most likely cause of the large percent error?

(A) The acceleration due to gravity is 70% greater than $9.80\ \text{m/s}^2$ at this location.
(B) The acceleration due to gravity is 70% less than $9.80\ \text{m/s}^2$ at this location.
(C) Air resistance increases the downward acceleration.
(D) The acceleration of the plastic balls is not uniform.
(E) The plastic balls are not truly spherical.

elimination

34. A car travels forward with constant velocity. It goes over a small stone, which gets stuck in the groove of a tire. The initial acceleration of the stone, as it leaves the surface of the road, is

(A) vertically upward
(B) horizontally forward
(C) horizontally backward
(D) zero
(E) upward and forward, at approximately 45° to the horizontal

35. The escape speed for a rocket at Earth's surface is v_e. What would be the rocket's escape speed from the surface of a planet with twice Earth's mass and the same radius as Earth?

(A) ~~$2v_e$~~
(B) $\sqrt{2}v_e$
(C) v_e
(D) $\frac{v_e}{\sqrt{2}}$
(E) $\frac{v_e}{2}$

$V_e = \sqrt{\frac{2GM}{r}}$ - escape velocity formula

2009:

4. A dart gun is used to fire two rubber darts with different but unknown masses, M_1 and M_2. The gun exerts the same constant force on each dart, but its magnitude F is unknown. The magnitudes of the accelerations of both darts, a_1 and a_2, respectively, are measured. Which of the following can be determined from these data?

(A) F only
(B) M_1 and M_2 only
(C) The ratio of M_1 and M_2 only
(D) F and the ratio of M_1 and M_2 only
(E) F, M_1, and M_2

$F = M_1 a \quad a_1 = \frac{F}{M_1}$

$F = M_2 a \quad a_2 = \frac{F}{M_2}$

$\frac{a_1}{a_2} = \frac{m_2}{m_1}$

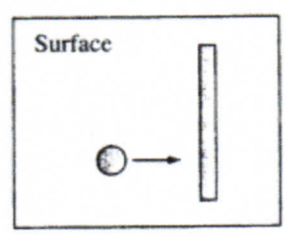
we know this

11. A student is asked to determine the mass of Jupiter. Knowing which of the following about Jupiter and one of its moons will allow the determination to be made?

I. The time it takes for Jupiter to orbit the Sun
II. The time it takes for the moon to orbit Jupiter
III. The average distance between the moon and Jupiter

(A) I only
(B) II only
(C) III only
(D) I and II
(E) II and III

$\frac{mv^2}{r} = \frac{GMm}{r^2} \quad v^2 = \frac{GM}{r}$



Top View

12. A disk sliding on a horizontal surface that has negligible friction collides with a rod that is free to move and rotate on the surface, as shown in the top view above. Which of the following quantities must be the same for the disk-rod system before and after the collision?

I. Linear momentum
II. Angular momentum
III. Kinetic energy

(A) I only
(B) II only
(C) I and II only
(D) II and III only
(E) I, II, and III

Momentum conserved

22. The object of mass m shown above is dropped from rest near Earth's surface and experiences a resistive force of magnitude kv, where v is the speed of the object and k is a constant. Which of the following expressions can be used to find v as a function of time t ? (Assume that the direction of the gravitational force is positive.)

(A) $\int_0^v \frac{dv}{mg - kv} = \int_0^t \frac{dt}{m}$

(B) $\int_0^t \frac{dv}{mg - kv} = \int_0^v \frac{dt}{m}$

(C) $\int_0^v \frac{dv}{kv} = \int_0^t \frac{dt}{m}$

(D) $\int_0^v (mg - kv)\, dv = \int_0^t m\, dt$

(E) $\int_0^v (mg - kv)\, dt = \int_0^t m\, dv$

$ma = mg - kv$

$a = \frac{dv}{dt}$

$m\left(\frac{dv}{dt}\right) = mg - kv$

$\int \frac{dv}{mg-kv} = \int \frac{dt}{m}$

27. A 5 kg object is propelled from rest at time $t = 0$ by a net force **F** that always acts in the same direction. The magnitude of **F** in newtons is given as a function of t in seconds by $F = 0.5t$. What is the speed of the object at $t = 4$ s?

(A) 0.5 m/s
(B) 0.8 m/s
(C) 2.0 m/s
(D) 4.0 m/s
(E) 8.0 m/s

$\int F(t) = \Delta p$

$\int_0^4 0.5t\, dt = 4$

$4 = (5\text{kg})(v)$

$v = 0.8\,\text{m/s}$

30. One end of a string is fixed. An object attached to the other end moves on a horizontal plane with uniform circular motion of radius R and frequency f. The tension in the string is F_s. If both the radius and frequency are doubled, the tension is

(A) $\frac{1}{4}F_s$

(B) $\frac{1}{2}F_s$

(C) $2F_s$

(D) $4F_s$

(E) $8F_s$

$\frac{2\pi r}{T} = v \quad T = \frac{1}{f}$

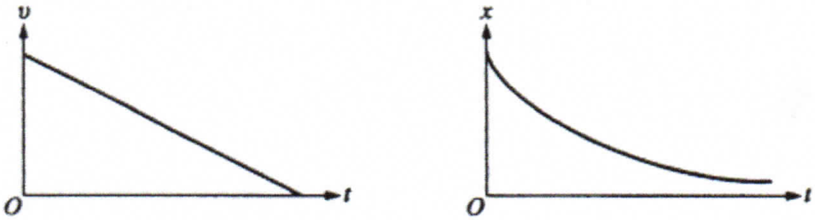
$\frac{mv^2}{r}$

$v = 2\pi r f$

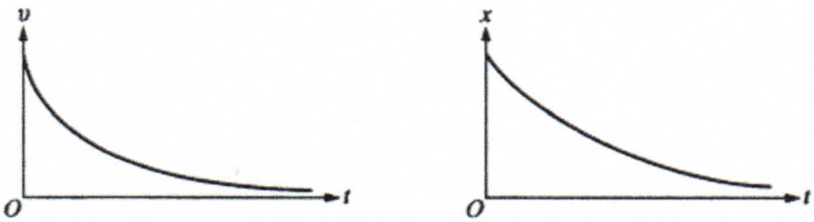
$\frac{m(2\pi r f)^2}{r} = \frac{2^2}{2} = \boxed{2}$

34. A car is traveling along a straight, level road when it runs out of gas at time $t = 0$. From this time on, the net force on the car is a resistive force of $-k\mathbf{v}$, where $\mathbf{v}$ is velocity and k is a constant. Which of the following pairs of graphs best represents the speed v and position x of the car as functions of time after $t = 0$?

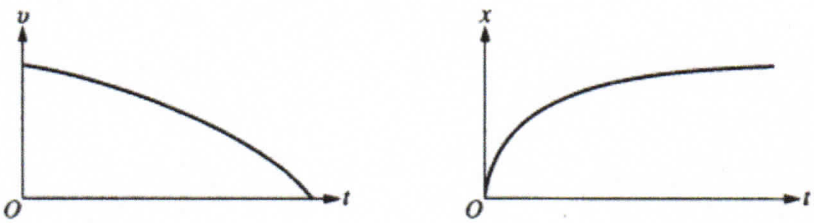
(A)



(B)



(C)



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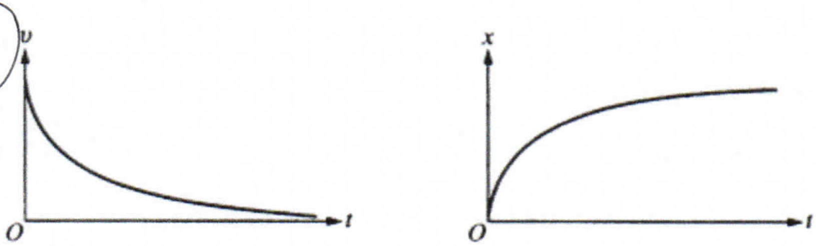

(E)