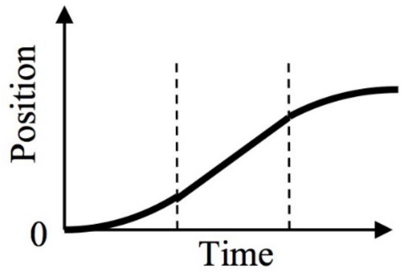
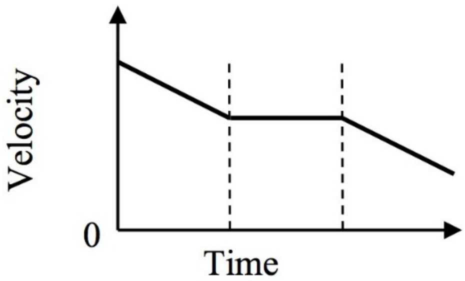
Question:



(1)上圖顯示一個沿著 x 軸方向運動的物體其位置和時間關係圖則下面哪一張圖為此物體在此相同時間範圍內的速度與時間關係圖?

a.



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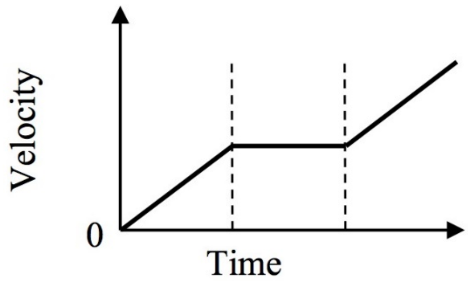
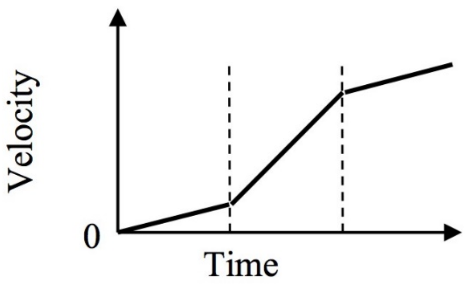
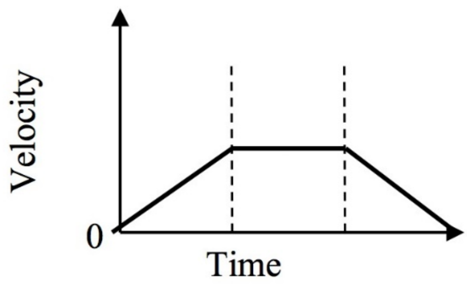


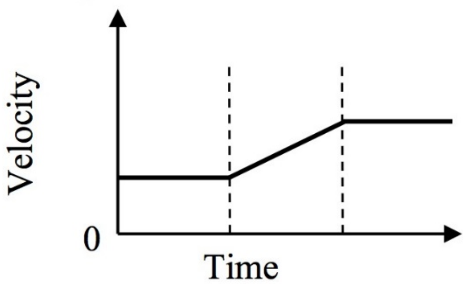
c.



d.



e.



Answer:

The correct answer is ***d***. Recall that velocity (=Δposition/Δtime) represents the slope of a *position-time* graph. A constant slope (straight line) on the position-time graph represents a flat line on the *velocity-time* graph, and a changing slope on the *position-time* graph will represent a changing velocity: increasing velocity for a concave upwards *position-time* curve, and decreasing velocity for a concave-down *position-time* curve.

Question:

(2) 從地表以與水平呈角度 30 度上拋一顆球進入空中，不計空氣阻力，則當球被釋放的那一瞬間，加速度為多少?

a. 向上 9.8 m/s^2
b. 向上 4.9 m/s^2
c. 向下 9.8 m/s^2
d. 0 m/s^2
e. 以上皆非

Answer:

The correct answer is *c*. The ball, even as it moves upwards and sideways through the air, experiences a force of gravity acting on it, which causes it to accelerate downwards at **g**.

Question:

(3) 一支砲管十公尺長的鉛直大砲加速一顆一公斤的球垂直向上進入空中，大砲的火藥相當於在該十公尺的砲管中提供一個 13.2 牛頓的固定施力，這顆球離開大砲的速度大約是多少(假設沒有來自摩擦力的能量損耗)?

a. 29 m/s
b. 16 m/s
c. 14 m/s
d. 9 m/s
e. 8 m/s

Answer:

The correct answer is *e*. This is a conservation of energy problem, with Work done on the ball contributing to increased potential and kinetic energies. Using **g** = 9.8 m/s^2:

$$W = U + K$$

$$Fd = mgh + \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2(Fd - mgh)}{m}}$$

$$v = \sqrt{\frac{2(13.2 \bullet 10 - 1 \bullet 10 \bullet 10)}{1}}$$

$$v = \sqrt{\frac{2(32)}{1}} = 8m/s$$

This constant net force / constant acceleration problem may also be solved using kinematics/ $F_{net} = ma$:

$$F_{net} = ma$$

$$F_{applied} - F_g = ma$$

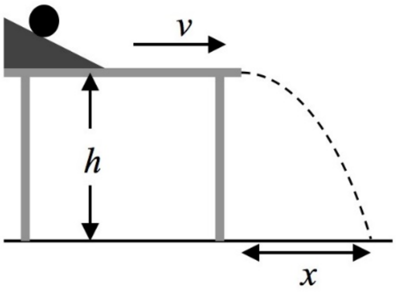
$$a = \frac{F_{applied} - F_g}{m} = \frac{13.2N - (1kg)(9.8m/s^2)}{1kg} = 3.4m/s^2$$

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$v_f = \sqrt{0^2 + 2(3.4m/s^2)(10m)} = 8.0m/s$$

Using **g** = 9.8 m/s^2 in either analysis will give a slightly more accurate answer of 8.25 m/s.

Question:



(4) 如圖，一顆球滾下一個斜坡，之後以水平速度 v 離開桌緣。若桌緣離地面的鉛直高度為 h，球在離桌緣多遠的距離 x 落地(假設忽略空氣阻力)?

a. $\frac{2v^2}{g}$

b. $v\sqrt{\frac{2h}{g}}$

c. $\frac{2vh}{g}$

d. $\frac{2h}{g}$

e. 以上皆非

Answer:

The correct answer is *b*. The ball takes a time *t* to fall from the table, as determined here:

$$\Delta y = v_0 t + \tfrac{1}{2}at^2$$

$$t = \sqrt{\frac{2\Delta y}{-g}} = \sqrt{\frac{2h}{g}}$$

Horizontally, during that time the ball travels at constant velocity:

$$\Delta x = vt$$

$$x = v\sqrt{\frac{2h}{g}}$$

Question:

(5) 一個物體被垂直拋向空中，不計空氣阻力，該物體的加速度為 9.8 m/s^2 向下，下列哪一個敘述是正確的?

a. 此物體在上升過程中，速度會增加到 9.8 m/s。
b. 此物體在上升過程中，每一秒行進 9.8 m。
c. 此物體在上升過程中，第一秒行進 9.8 m。
d. 此物體在上升過程中，每一秒速度改變 9.8 m/s。
e. 此物體在上升過程中，加速度對時間的積分是 9.8 m/s。

Answer:
The correct answer is ***d***. By definition, an object accelerating at 9.8m/s, *per second*, has a velocity that changes by that amount.

While choice *e* is correct in identifying a velocity as the integral (with respect to time) of acceleration, the actual value of that integral will vary depending on the conditions (initial velocity, etc) of the problem.

Question:

(6）一台馬戲團的人體大砲以與水平呈角度 45 度發射一個雜技演員進入空中，此雜技演員到達的最大鉛直高度為 y。若將發射方式改變成垂直向上發射，雜技演員可到達的最大鉛直高度為(假設忽略空氣阻力)?

a. y

b. $\frac{y}{2}$

c. $2y$

d. $y\sqrt{2}$

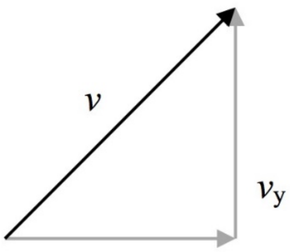
e. $\frac{2y}{\sqrt{2}}$

Answer:

The correct answer is *c*. The acrobat reaches her height in the first instance based on the initial vertical component of velocity, v_y:

$$v_f{}^2 = v_i{}^2 - 2ay$$

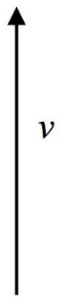
$$y = \frac{0 - v_i{}^2}{-2g} = \frac{v_i{}^2}{2g}$$



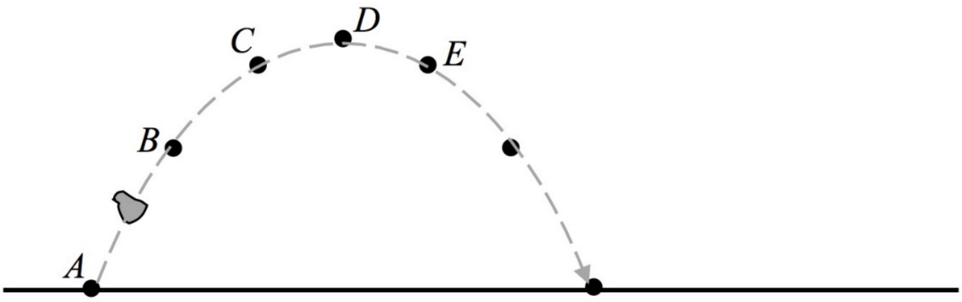
For the second situation, the vertical velocity v is greater than v_y from before, by a factor of $\sqrt{2}$. Using this information:

$$y' = \frac{(v_i')^2}{2g}$$

$$y' = \frac{(v\sqrt{2})^2}{2g} = \frac{2v^2}{2g} = 2y$$



Question:



(7) 一顆石頭以與水平呈某個角度被拋向空中，不計空氣阻力，該石頭在圖中 D 點的淨加速度方向為何?

a. 向左。

b. 向右。

c. 向上。

d. 向下。

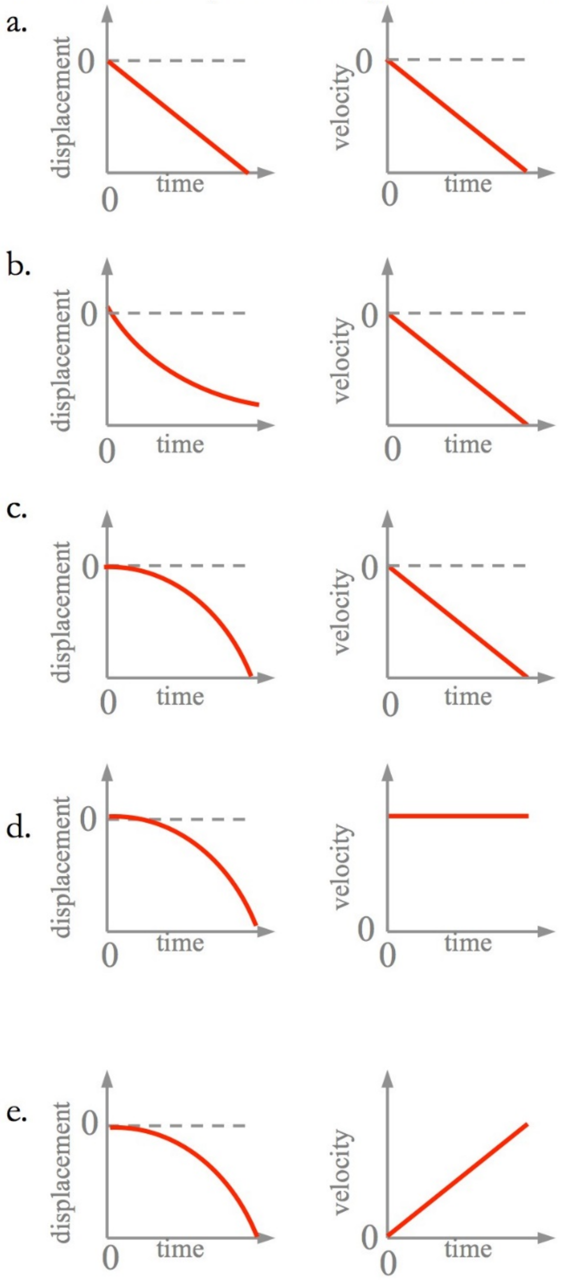
e. 在 D 點沒有加速度。

Answer:

The correct answer is ***d***. The rock has constant horizontal velocity, and therefore no horizontal acceleration. Vertically, the rock's velocity is constantly changing, slowing down as it ascends, and speeding up as it falls. Its net acceleration, or change in velocity per unit time, is always in the downward direction.

Question:

（8）某物體從離地高度 h 處自由落下，下列哪兩張圖正確描述該物體位移及速度隨時間的變化?（座標原點選在起始高度 h 的位置，向上為正，向下為負）



Answer:

The correct answer is *c*. The object begins to fall from a height *h* in the negative direction, accelerating as it falls, so it's covering a greater and greater distance per unit time. This is consistent with the displacement graphs a, c, d, and e. The object's speed increases with time, but its velocity is in the downward, or negative direction, as indicated in the velocity-time graph for answer *c*.

Question:

(9) 一輛玩具車在一條直線上以等速度 v=30 cm/s 移動，接著以一個固定的加速度 a=-3cm/s^2 開始煞車，請問從煞車開始計算，車子完全停下來要花多少時間?

a. 10 s

b. 9 s

c. 900 s

d. 1 s

e. 90 s

Answer:

The correct answer is ***a***. Slowing down at 3.0 cm/s, every second, implies that the car will take 10 seconds to go from 30, to 27, to 24, to 21 cm/s, etc., all the way down to 0.

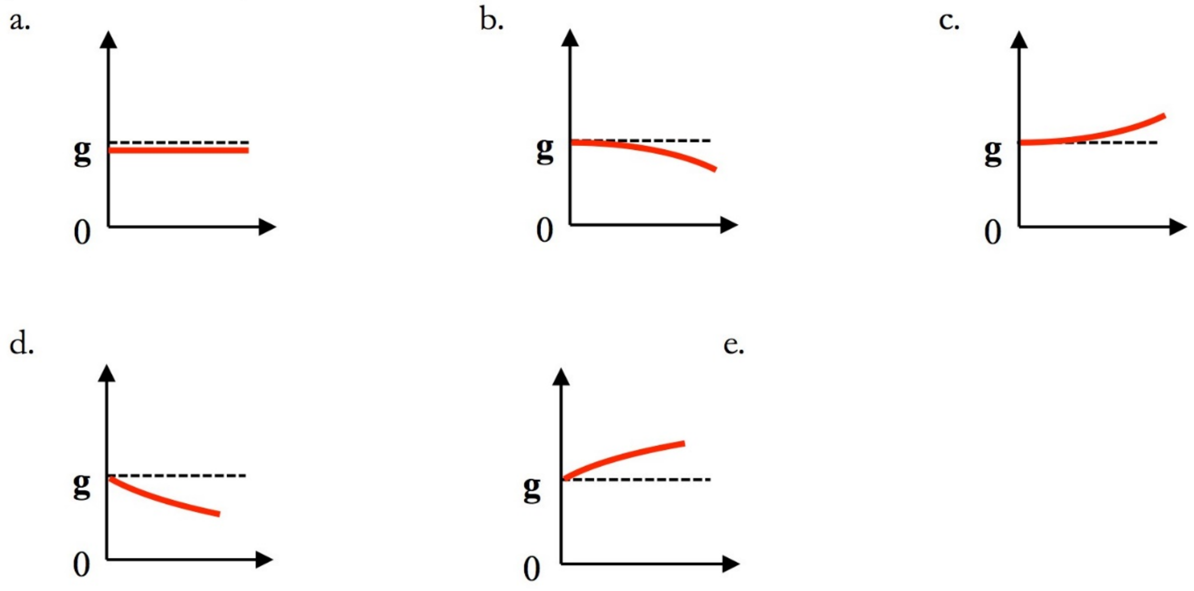
The kinematics analysis reveals this as well. Giving the car an initial positive velocity means that the acceleration for “slowing down” will have to be in the opposite direction of that motion, i.e. negative:

$$v_f = v_i + at$$

$$t = \frac{v_f - v_i}{a} = \frac{0 - 30cm/s}{-3.0cm/s^2} = 10s$$

Question:

(10) 某物體從高處自由落下，過程中受到空氣阻力的影響，但該物體速度尚未達到終端速度，下列哪一張圖代表過程中物體所受加速度隨時間的變化?

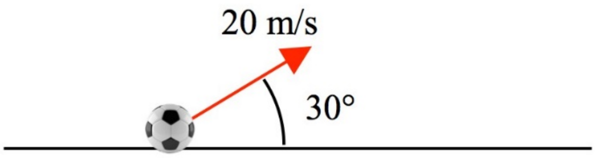


Answer:

The correct answer is ***d***. The falling object, when released from rest, has an initial acceleration of 9.8 m/s^2 (if near the surface of the earth). As its velocity increases, it collides with air molecules at an increasing rate, thus reducing the rate at which it accelerates. (The acceleration is usually modeled as a function of v or v^2, depending on a number of factors.) The acceleration continues to decrease until the acceleration of the object is 0, at which point the velocity of the falling object remains constant.

The only graph consistent with this analysis is *d*, where the acceleration curve can be seen to be approaching zero asymptotically.

Question:



(11) 如圖所示一顆足球以初速 20 m/s 與地面呈 30 度被踢出去，不計空氣阻力，則這顆球所能到達的最大高度約為?

a. 10 m
b. 1 m
c. 5 m
d. 20 m
e. 15 m

Answer:

The correct answer is *c*. To determine the vertical height reached by the ball, we focus only on the vertical aspects of the ball's motion.

The ball has an initial vertical velocity of 20 sin 30, or 10 m/s. The ball's final vertical velocity at the top of its path is 0 m/s. Using kinemati
can be determined:

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$\Delta y = \frac{v_f^2 - v_i^2}{2a} = \frac{0^2 - (10m/s)^2}{2(-10m/s^2)} = 5m$$

The ball has a horizontal aspect to its motion as well, of course—a horizontal velocity of 20 cos 30 = 17.3 m/s, and no acceleration—but these qualities are independent of the ball's vertical motion.

Question:

(12) 某學生收集了一個物體的位置(x)與時間(t)的數據，發現物體沿著x軸的運動滿足了數學關係式$x = 1.5t^2 + 2.0t - 1.0$，其中x的單位是公尺，其中t的單位是秒，則我們可以得到什麼訊息?

a. 在時間 t=0，該物體在原點。
b. 在時間 t=0，該物體擁有初速 1 m/s。
c. 在時間 t=0，該物體擁有初加速度 1.5 m/s^2。
d. 在運動過程中，該物體的加速度隨著時間的平方改變。
e. 以上皆非。

Answer:

The correct answer is *e*. We can use the position-time function for the object to identify the objects position, velocity, and acceleration in a couple of different ways.

The calculus approach is based on the fact that $v = \frac{dx}{dt}$, and $a = \frac{d^2x}{dt^2}$, or $a = \frac{dv}{dt}$. Applying these relationships to the model, we see that

$$v = \frac{d}{dt}\left(1.5t^2 + 2t - 1\right) \qquad \text{and} \qquad a = \frac{d}{dt}\left(3t + 2\right)$$

$$v = 3t + 2 \qquad\qquad a = 3$$

By using $t = 0$ in the $x(t)$, $v(t)$, and $a(t)$ equations we can see that none of the statements *a-d* are true. Instead, at time $t = 0$ the object has an intial position of -1.0 m, a velocity of 2.0 m/s, and an acceleration (constant throughout its motion) of 3.0 m/s^2.

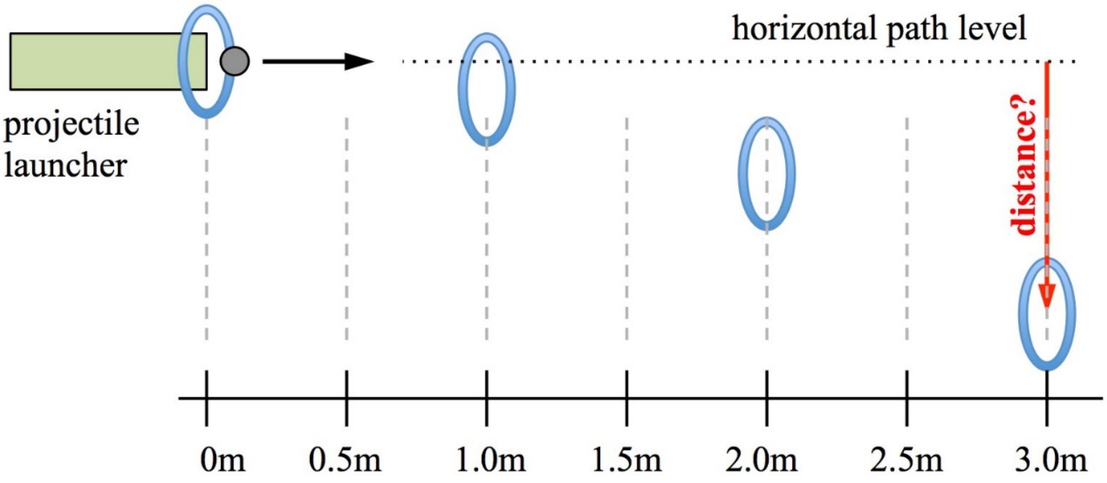
A non-calculus approach to solving this problem would consist of comparing the equation with the kinematics equation $x_f = x_i + v_i t + \frac{1}{2}at^2$. Rearrange this kinematics equation and compare it with the equation of the object's motion:

$$x_f = \frac{1}{2}at^2 + v_i t + x_i$$

$$x = 1.5t^2 + 2.0t - 1.0$$

Here we can clearly identify the same initial position, the initial velocity, and the acceleration of the object according to the terms and coefficients in the equations.

Question:



(13) 如圖，一位老師想要演示拋體運動讓學生看，他準備了一個發射器放在建築物頂端，水平發射一顆球後，預計該球會陸續穿過幾個懸空架設的環。若球的初速為 2 m/s 且不計空氣阻力，第四個環要架設在水平虛線下方多遠處?

a. 1.5 m

b. 3.0 m

c. 4.5 m

d. 6.0 m

e. 11 m

Answer:

The correct answer is ***e***. A horizontal analysis of the ball reveals that it will reach ring 4 in 1.5 seconds:

$$\Delta x = v_x t$$

$$t = \frac{\Delta x}{v_x} = \frac{3.0m}{2.0m/s} = 1.5s$$

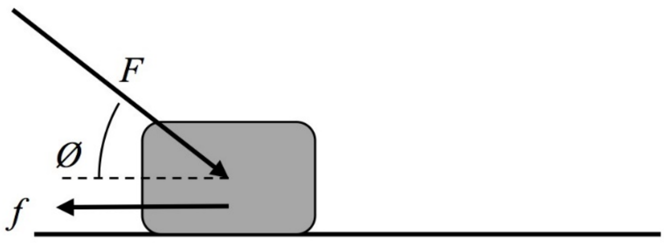
During that time, the vertical distance that the ball falls can be determined:

$$\Delta y = v_i t + \frac{1}{2}at^2$$

$$\Delta y = 0t + \frac{1}{2}(-10m/s^2)(1.5s)^2 = 5 \bullet 2.25 = -11m$$

You can also estimate the distance that the ball has traveled during the 1.5 seconds by using average velocity: the accelerating ball has an average velocity of 5m/s during its first second of travel. After one second of falling the ball will have dropped 5.0 meters. In the additional half-second of travel the ball will be moving even faster, making the 11 meter answer the logical result.

Question:



(14) 如圖，一個質量 m 的積木在粗糙表面上被施加一個力 F 而移動，此力與水平夾角為 ϕ，積木在運動過程中受到一個反方向的摩擦力 f，求積木與粗糙表面間的摩擦係數?

a. $\dfrac{mg}{F\sin\phi}$

b. $\dfrac{f}{F\sin\phi + mg}$

c. $\dfrac{f}{mg}$

d. $\dfrac{mg}{f}$

e. $\dfrac{f}{F\sin\phi - mg}$

Answer:

The correct answer is *b*. The key to finding the coefficient of friction μ is in calculating the correct Normal force acting on the block.

$$\sum F_y = ma$$

$$-F_{applied-y} - F_g + F_{Normal} = 0$$

$$F_{Normal} = F\sin\phi + mg$$

$$\mu = \frac{F_{friction}}{F_{Normal}} = \frac{f}{F\sin\phi + mg}$$

Question:

(15) 火星對它的衛星 Phobos 施加萬有引力 F_{Mars} ，Phobos(其質量比火星小)也對火星施加一個萬有引力 F_{Phobos} ，下列敘述何者正確?

a. $F_{Mars} > F_{Phobos}$ 。

b. $F_{Phobos} > F_{Mars}$ 。

c. $F_{Phobos} = F_{Mars}$ 。

d. F_{Phobos}, F_{Mars} 兩者的大小取決於火星和 Phobos 之間的距離。

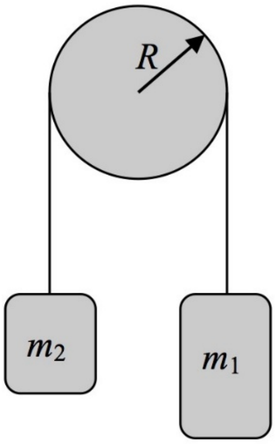
e. F_{Phobos}, F_{Mars} 兩者的大小取決於火星的另一顆衛星 Deimos 的所在位置。

Answer:

The correct answer is *c*. The force of gravitational attraction between any two masses is equal, and given by $F = G\frac{m_1 m_2}{r^2}$.

The magnitude of this force varies with distance *r*, of course, but at any given distance, the forces between the two bodies are equal. And while the presence of the second moon will affect the *net* force of gravitational attraction acting on a body, it doesn't change the force exerted by a different body.

Question:



(16) 如圖所示，兩個物體以一條很輕的繩子連接，懸掛在一個無摩擦力且不計質量的滑輪上。若質量 m_1=3 Kg 且 m_2=2 Kg，從靜止釋放兩物體，兩物體的加速度大約為何?

a. 1 m/s^2
b. 2 m/s^2
c. 4 m/s^2
d. 6 m/s^2
e. 8 m/s^2

Answer:

The correct answer is *b*. This is a Newton's Second Law problem, using $F_{net} = ma$, where F_{net} = the net force acting on the pulley, and *m* refers to the total mass of the system.

$$F_{net} = ma$$

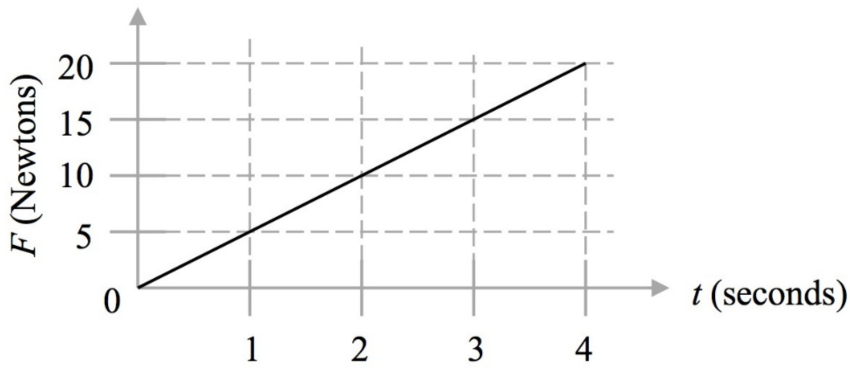
$$a = \frac{F_{net}}{m}$$

$$a = \frac{F_3 - F_2}{m}$$

$$a = \frac{3kg(\mathbf{g}) - 2kg(\mathbf{g})}{(2kg + 3kg)}$$

$$a = \frac{1}{5}\mathbf{g} \approx 2m/s^2$$

Question:



(17) 施一個水平方向的力 *F* 推動一塊積木沿著一個無摩擦力的表面上移動，如圖所示，此力隨著時間在改變。若 t=3 seconds 時，積木的加速度為 5 m/s^2，積木的質量為何?

a. 1 Kg
b. 2 Kg
c. 3 Kg
d. 5 Kg
e. 15 Kg

Answer:

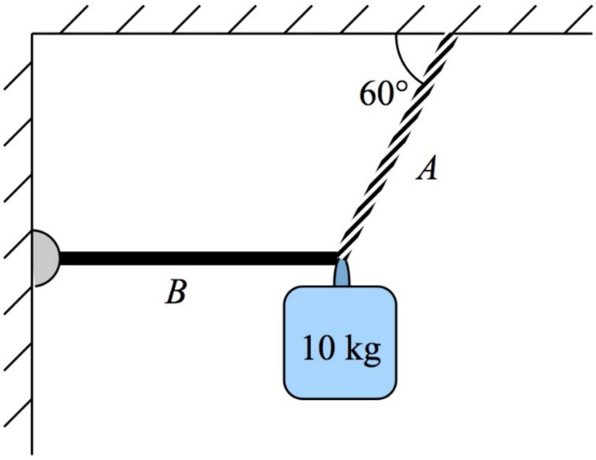
The correct answer is *c*. The relationship between the force acting on the block, its mass, and acceleration is described by F=*m*a.

$$F_{net} = ma$$

$$15N = m(5m/s^2)$$

$$m = 3kg$$

Question:



(18) 如圖，一個質量 10 Kg 的物體連接一條 A 纜線和另一根質量極輕的 B 橫桿懸吊著，若 B 橫桿左端的支點可以自由旋轉，則 A 纜線所受的張力大約多少牛頓?

a. $\frac{100}{\sqrt{3}}$

b. $100\sqrt{3}$

c. $\frac{200}{\sqrt{2}}$

d. $200\sqrt{3}$

e. $\frac{200}{\sqrt{3}}$

Answer:

The correct answer is *e*. The weight of the mass, approximately 100N, must be entirely supported by the vertical component of the tension in the cable, F_y. Therefore:

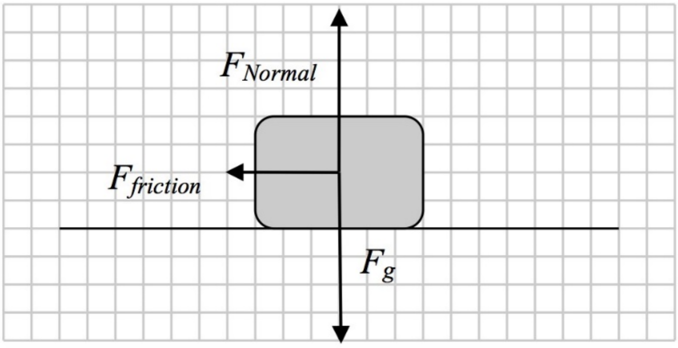
$$\sum F_y = ma$$

$$F_y - F_g = 0$$

$$F_y = F_{Tension} \sin 60 = (10kg)(\sim 10m/s^2)$$

$$F_{Tension} = \frac{100N}{\sqrt{3}/2} = 200/\sqrt{3}$$

Question:



(19) 如圖所示為一個箱子的受力總圖，三個力的大小和對應的向量箭頭長度成比例，下列哪一個敘述是正確的?

a. 因為箱子受到向左的摩擦力，所以箱子一定正在往左運動。

b. 因為箱子受到向左的摩擦力，所以箱子一定正在往右加速。

c. 因為箱子受到向左的摩擦力，所以箱子一定正在往右運動。。

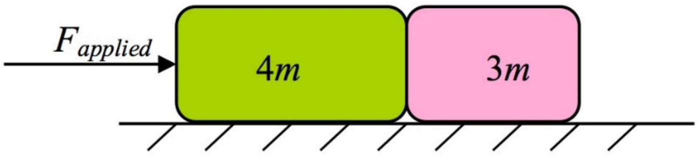
d. 這張圖畫得不正確，除非箱子在動，否則不受任何摩擦力。

e. 以上敘述皆不正確。

Answer:

The correct answer is *c*. The diagram suggests that the box is currently moving to the right, and in the process of slowing down due to a force of friction that is causing it to accelerate in the opposite direction (slowing down the box).

Question:



(20) 如圖，一個力 $F_{applied}$ 施加在一對未連結的物體上，兩物體質量分別為 4m 與 3m，坐落在一個無摩擦力的表面上，求兩物體之間的互相施力或受力大小為何?

a. $F_{applied}$

b. $2F_{applied}$

c. $\frac{3}{4}F_{applied}$

d. $\frac{3}{7}F_{applied}$

e. $\frac{4}{7}F_{applied}$

Answer:

The correct answer is *d*. The problem can be solved by drawing two separate free-body diagrams and solving $F_{net} = ma$ for each body, then substituting and solving to get the required force. It's probably easier and faster, however, to solve $F_{net} = ma$ for the system as a whole to find acceleration...

$$F_{net} = ma$$

$$F_{applied} = (4m + 3m)a$$

$$a = \frac{F_{applied}}{7m}$$

...and then use this acceleration with the mass 3*m* to get the force acting between the masses:

$$F_{net} = ma$$

$$F_{on\ 3m\ from\ 4m} = (3m)\left(\frac{F_{applied}}{7m}\right)$$

$$F = \frac{3}{7}F_{applied}$$

Question:

(21) 兩個物體(質量分別為 M 與 m，且 M > m)以一條很輕的繩子連結，懸掛在一個不計質量的滑輪上，由靜止狀態釋放後，求兩物體的加速度大小為何?

a. $\left(\frac{M+m}{M-m}\right)g$

b. $\left(\frac{M-m}{M+m}\right)g$

c. $\left(\frac{M}{M+m}\right)g$

d. $\left(\frac{m}{M+m}\right)g$

e. $\left(\frac{M - m}{M}\right)g$

Answer:

The correct answer is *b*. We can analyze this situation by drawing a picture and doing a free-body diagram for each of the two masses, as shown here. Because the pulley has negligible mass, the force of Tension between the two masses is equal (by Newton's 3rd Law), and we can use Newton's 2nd Law to determine the acceleration of the system:

$M: \quad F_{net} = ma = Ma$

$\quad Mg - F_{Tension} = Ma$ (where "down" is positive)

$m: \quad F_{net} = ma$

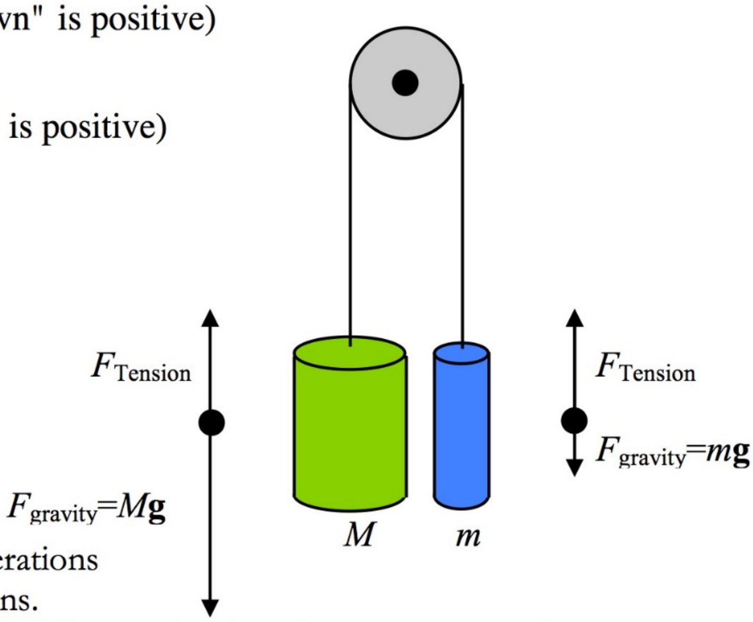
$\quad F_{Tension} - mg = ma$ (where "up" is positive)

Combine equations and solve:

$$Mg - (ma + mg) = Ma$$

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

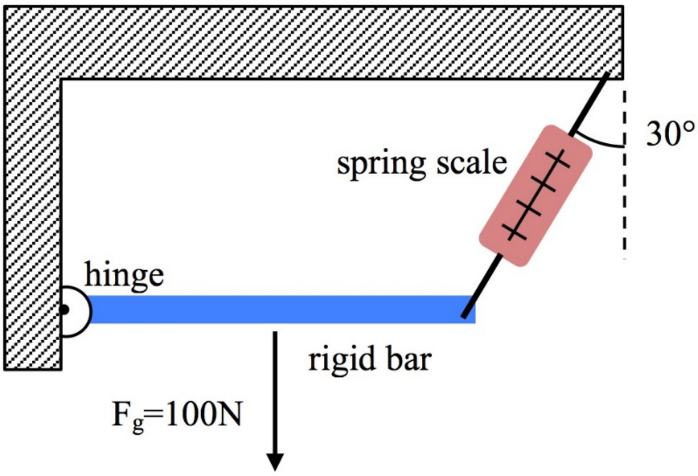
$$a = \left(\frac{M-m}{M+m}\right)g$$



Notice that we have selected different frames of reference for the two masses (for *m*, "up" is positive; for *M*, "down" is positive) so that the accelerations of the masses will have identical directions.

If we don't adjust our analysis to take the different directions into account, we'll get an incorrect result when we combine the two equations.

Question:



(22) 如圖，一根重量 100 牛頓的剛硬棒子，左端連接一個可以自由旋轉的無摩擦力樞紐，右端由一條彈簧秤水平支撐著，此彈簧秤的右上方懸掛在天花板上，彈簧秤與鉛直方向的夾角為 30°，求彈簧秤的張力讀值為何？

a. 100 N

b. $100\sqrt{3}$ N

c. $100/\sqrt{3}$ N

d. $50/\sqrt{3}$ N

e. 50 N

Answer:

The correct answer is *c*. The problem can be solved in two ways. The bar is being held in static equlibrium, so the sum of the torques acting on the bar has to be zero. Taking the hinge to be $x = 0$, one can add up the torque due to the force of gravity down (acting at the center of mass) and the torque due to the spring scale up.

More simply, the sum of the forces in the vertical direction has to be 0. Therefore:

$$\sum F_y = ma = 0$$

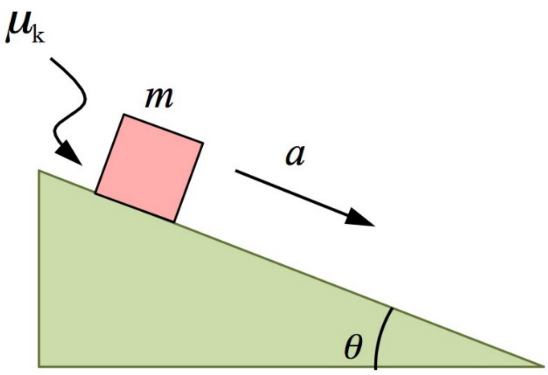
$$F_{hinge} - F_{gravity} + F_{y-springscale} = 0$$

Hinge and spring scale are equidistant from the center of mass, so each supports 50N.

$$F_{y-springscale} = 50N = F_{springscale} \cos 30$$

$$F_{springscale} = \frac{50}{\sqrt{3}/2} = \frac{100}{\sqrt{3}} N$$

Question:



(23) 如圖，一個積木(質量 m)被放置在一個斜面上，斜面的傾斜角度為θ，當積木向下加速滑動時，動摩擦係數為μ_k ，求積木的加速度大小為何？

a. $mg\sin\theta - mg\cos\theta$

b. $mg\sin\theta - \mu mg\cos\theta$

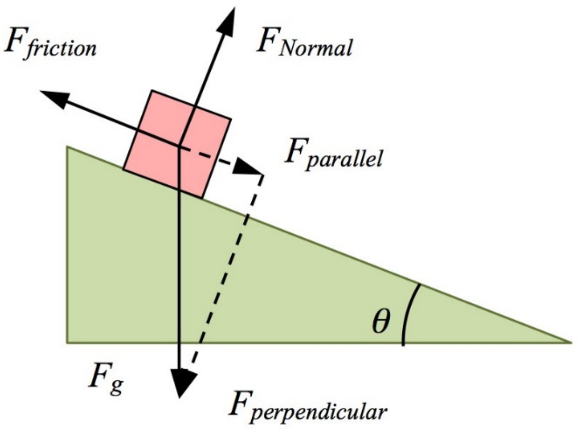
c. $mg\sin\theta - \mu mg$

d. $g\sin\theta - g\cos\theta$

e. $g\sin\theta - \mu g\cos\theta$

Answer:

The correct answer is *e*. A free-body diagram of the forces acting on the block and an analysis using Newton's Second Law $F_{net} = ma$ yields the answer.



$$x - direction\ (down\ the\ ramp): F_{net} = ma$$

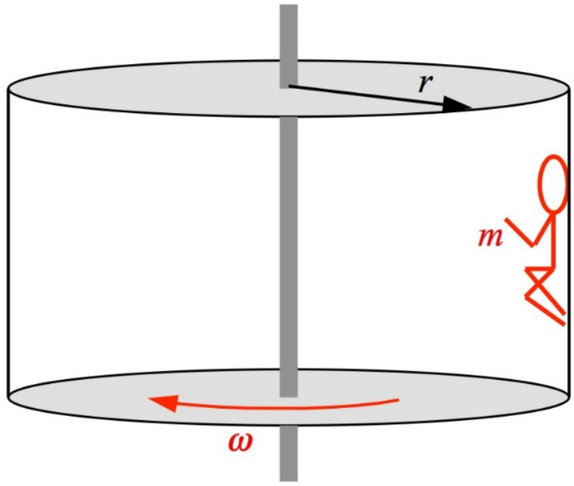
$$F_{parallel} - F_{friction} = ma$$

$$F_{friction} = \mu F_{Normal},\ and\ F_{Normal} = F_{perpendicular} = mg\cos\theta$$

$$mg\sin\theta - \mu mg\cos\theta = ma$$

$$a = g\sin\theta - \mu g\cos\theta$$

Question:



(24) 遊樂園裡面有一種遊樂器材由一個中空圓柱體構成，搭乘人員如圖所示，背貼著圓柱的牆上等待圓柱體旋轉，當圓柱體旋轉到速度夠快時，搭乘人員能夠抬起他的腳，不著地維持在牆面上，已知搭乘人員質量 m，圓柱體半徑 r，搭乘人員與背後牆面的靜摩擦係數為 μ，求搭乘人員不滑落的最小圓柱體旋轉角速度為何?

a. $\sqrt{\frac{g}{\mu r}}$ b. μmg c. $\sqrt{r\mu g}$ d. $\sqrt{\frac{\mu g}{r}}$ e. μrg

Answer:

The correct answer is ***a***. A free-body analysis of the student against the wall of the cylinder shows that the friction Force *f* must be equal to the force of gravity *mg*, and that the normal force F_{Normal} acts as a centripetal force to keep the student moving in a circle.

Putting those pieces together, then:

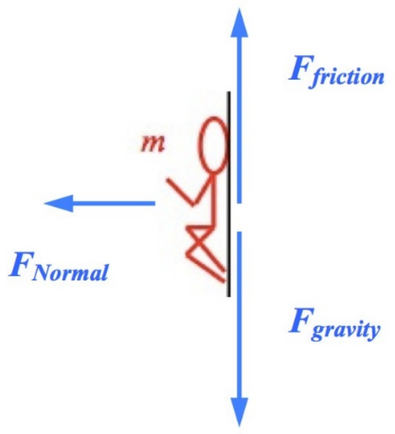
$$\sum F_x = \frac{mv^2}{r} = F_N$$

$$\sum F_y = F_{friction} - F_{gravity} = 0,\ so\ F_f = mg$$

$$F_f = \mu F_N\ \ and\ \ v = r\omega$$

Solve to get:

$$\omega = \sqrt{\frac{g}{\mu r}}$$



Question:

（25）某質量 m 的物體在三度空間中受到三個外力 F_1，F_2，and F_3。已知 F_1 指向正 x 方向，F_2 指向正 y 方向，而且 F_1 和 F_2 的大小相同，若此物體加速度為零，下列哪個敘述錯誤?

a. F_3 和 F_1 的大小相同。

b. 此物體處在力平衡狀態，可能是靜止的，沒在移動。

c. F_3 處在 x-y 平面上。

d. 此物體處在力平衡狀態，可能正在移動。。

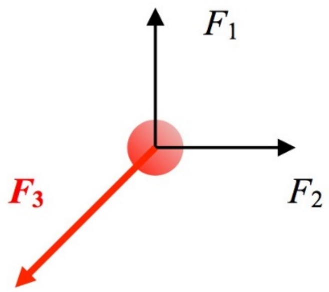
e. 此物體所受淨力為零。

Answer:

The correct answer is ***a***. By definition, the object is in equilibrium, either static (unmoving) or dynamic (moving with a constant velocity). If the object has acceleration $a = 0$, the net force acting on the mass must be 0 as well:

$$F_{net} = ma$$

$$F_{net} = m(0) = 0$$



With forces F_1 and F_2 in the *x-y* plane, the force that will counteract them must lie in the *x-y* plane as well, as shown. The magnitude of that force F_3 is equal to the vector sum of F_1 and F_2, and can be calculated as follows:

$$\sum F_x = 0 = \vec{F}_2 - \vec{F}_{3-x}$$

$$\sum F_y = 0 = \vec{F}_1 - \vec{F}_{3-y}$$

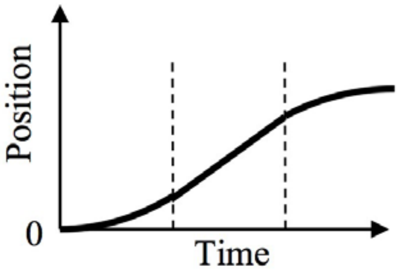
$$|F_3| = \sqrt{F_{3-x}{}^2 + F_{3-y}{}^2}$$

$$= \sqrt{F_1{}^2 + F_2{}^2}$$

$$= F_1\sqrt{2}$$

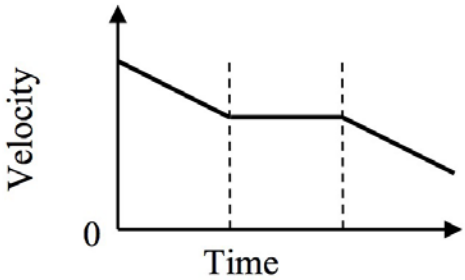
Both graphically and analytically, we can see that the magnitude of F_3 is not the same as that of F_1.

Question:

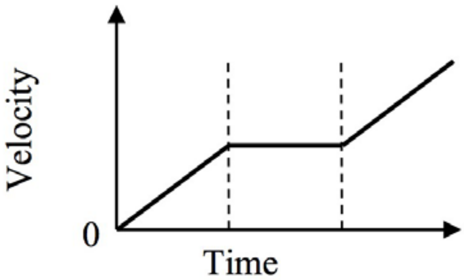


The graph given here shows the *position* vs. *time* for an object traveling along the *x*-axis. Which graph below shows the *velocity* vs. *time* for this same object during the same time period?

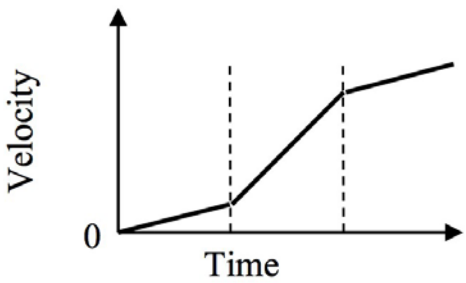
a.



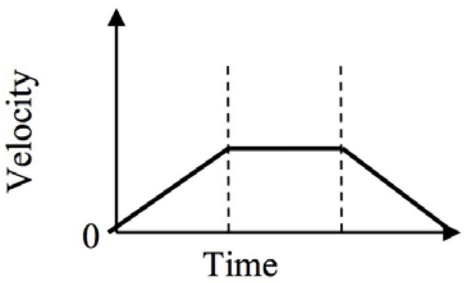
b.



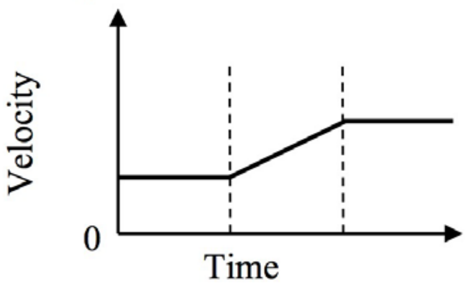
c.



d.



e.



Answer:

The correct answer is ***d***. Recall that velocity (=Δposition/Δtime) represents the slope of a *position-time* graph. A constant slope (straight line) on the position-time graph represents a flat line on the *velocity-time* graph, and a changing slope on the *position-time* graph will represent a changing velocity: increasing velocity for a concave upwards *position-time* curve, and decreasing velocity for a concave-down *position-time* curve.

Question:

Consider a ball thrown up from the surface of the earth into the air at an angle of 30° above the horizontal. Air friction is negligible. Just *after* the ball is released, its acceleration is:

a. Upwards at 9.8 m/s^2
b. Upwards at 4.9 m/s^2
c. Downwards at 9.8 m/s^2
d. 0 m/s^2
e. None of these

Answer:

The correct answer is *c*. The ball, even as it moves upwards and sideways through the air, experiences a force of gravity acting on it, which causes it to accelerate downwards at **g**.

Question:

A 10-meter long, vertical cannon is used to accelerate a 1.0-kg ball straight up into the air. A constant force of 13.2-Newtons is used to accelerate the bowling ball up the length of the cannon. What is the ball's approximate velocity as it leaves the cannon (assuming no energy loss to friction)?

a. 29 m/s
b. 16 m/s
c. 14 m/s
d. 9 m/s
e. 8 m/s

Answer:

The correct answer is *e*. This is a conservation of energy problem, with Work done on the ball contributing to increased potential and kinetic energies. Using **g** = 9.8 m/s^2:

$$W = U + K$$

$$Fd = mgh + \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2(Fd - mgh)}{m}}$$

$$v = \sqrt{\frac{2(13.2 \bullet 10 - 1 \bullet 10 \bullet 10)}{1}}$$

$$v = \sqrt{\frac{2(32)}{1}} = 8m/s$$

This constant net force / constant acceleration problem may also be solved using kinematics/ $F_{net} = ma$:

$$F_{net} = ma$$

$$F_{applied} - F_g = ma$$

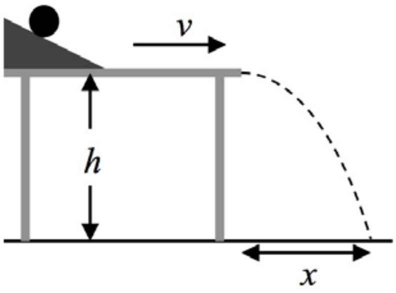
$$a = \frac{F_{applied} - F_g}{m} = \frac{13.2N - (1kg)(9.8m/s^2)}{1kg} = 3.4m/s^2$$

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$v_f = \sqrt{0^2 + 2(3.4m/s^2)(10m)} = 8.0m/s$$

Using **g** = 9.8 m/s^2 in either analysis will give a slightly more accurate answer of 8.25 m/s.

Question:



In a lab experiment, a ball is rolled down a ramp so that it leaves the edge of the table with a horizontal velocity *v*. If the table has a height *h* above the ground, how far away from the edge of the table, a distance *x*, does the ball land? You may neglect air friction in this problem.

a. $\frac{2v^2}{g}$

b. $v\sqrt{\frac{2h}{g}}$

c. $\frac{2vh}{g}$

d. $\frac{2h}{g}$

e. none of these

Answer:

The correct answer is *b*. The ball takes a time *t* to fall from the table, as determined here:

$$\Delta y = v_0 t + \tfrac{1}{2}at^2$$

$$t = \sqrt{\frac{2\Delta y}{-g}} = \sqrt{\frac{2h}{g}}$$

Horizontally, during that time the ball travels at constant velocity:

$$\Delta x = vt$$

$$x = v\sqrt{\frac{2h}{g}}$$

Question:

An object thrown straight up into the air, in the absence of air friction, accelerates at 9.8 m/s^2, downward. Which of the following statements is true?

a. The object speeds up at 9.8 m/s as it travels upward.
b. The object travels 9.8 m during every second of its motion.
c. The object travels 9.8 m during the first second of its motion.
d. The object's velocity changes by 9.8 m/s every second of its motion.
e. The integral of its acceleration as a function of time is 9.8 m/s.

Answer:

The correct answer is ***d***. By definition, an object accelerating at 9.8m/s, *per second*, has a velocity that changes by that amount.

While choice *e* is correct in identifying a velocity as the integral (with respect to time) of acceleration, the actual value of that integral will vary depending on the conditions (initial velocity, etc) of the problem.

Question:

A circus cannon fires an acrobat into the air at an angle of 45° above the horizontal, and the acrobat reaches a maximum height y above her original launch height. The cannon is now aimed so that it fires straight up into the air at an angle of 90° to the horizontal. What is the maximum height reached by the same acrobat now?

a. y

b. $\frac{y}{2}$

c. $2y$

d. $y\sqrt{2}$

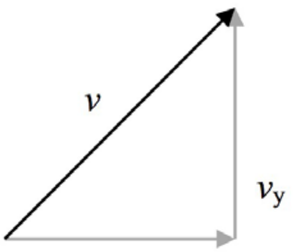
e. $\frac{2y}{\sqrt{2}}$

Answer:

The correct answer is *c*. The acrobat reaches her height in the first instance based on the initial vertical component of velocity, v_y:

$$v_f^{\,2} = v_i^{\,2} - 2ay$$

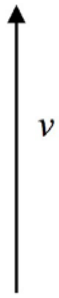
$$y = \frac{0 - v_i^{\,2}}{-2g} = \frac{v_i^{\,2}}{2g}$$



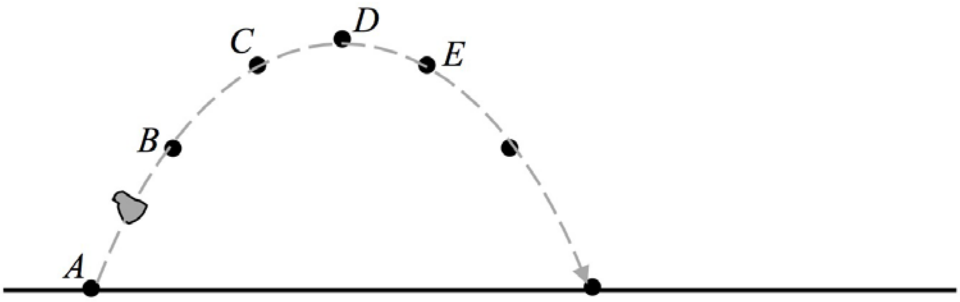
For the second situation, the vertical velocity v is greater than v_y from before, by a factor of $\sqrt{2}$. Using this information:

$$y' = \frac{(v_i')^2}{2g}$$

$$y' = \frac{(v\sqrt{2})^2}{2g} = \frac{2v^2}{2g} = 2y$$



Question:



A rock is thrown into the air at an angle relative to the vertical, and follows the path shown here. Consider air friction to be negligible. What is the direction of the net acceleration of the rock at point *D*?

a. to the left
b. to the right
c. straight up
d. straight down
e. there is no net acceleration at point *D*

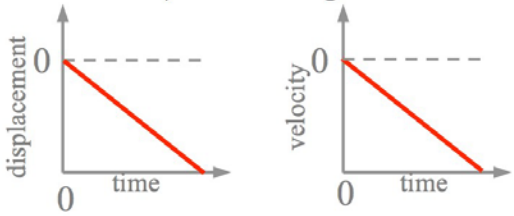
Answer:

The correct answer is ***d***. The rock has constant horizontal velocity, and therefore no horizontal acceleration. Vertically, the rock's velocity is constantly changing, slowing down as it ascends, and speeding up as it falls. Its net acceleration, or change in velocity per unit time, is always in the downward direction.

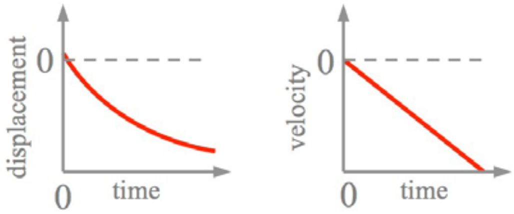
Question:

A mass is dropped from a height *h* above the ground, and freely falls under the influence of gravity. Which graphs here correctly describe the displacement and velocity of the object during the time the object is falling? Consider the "up" direction to be positive.

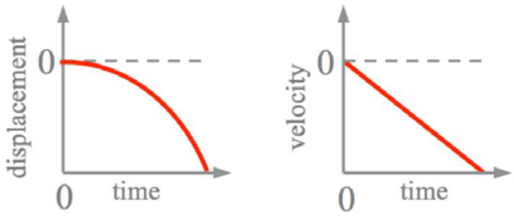
a.



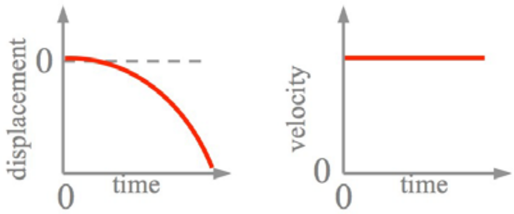
b.



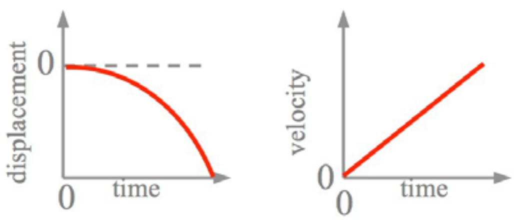
c.



d.



e.



Answer:

The correct answer is *c*. The object begins to fall from a height *h* in the negative direction, accelerating as it falls, so it's covering a greater and greater distance per unit time. This is consistent with the displacement graphs a, c, d, and e. The object's speed increases with time, but its velocity is in the downward, or negative direction, as indicated in the velocity-time graph for answer *c*.

Question:
A toy car, initially travelling in a straight line at 30.0 cm/s, slows down with a constant linear acceleration of 3.0 cm/s^2. How much time passes before the car comes to a halt?

a. 10 s
b. 9.0 s
c. 900 s
d. 1.0 s
e. 90 s

Answer:
The correct answer is ***a***. Slowing down at 3.0 cm/s, every second, implies that the car will take 10 seconds to go from 30, to 27, to 24, to 21 cm/s, etc., all the way down to 0.

The kinematics analysis reveals this as well. Giving the car an initial positive velocity means that the acceleration for "slowing down" will have to be in the opposite direction of that motion, i.e. negative:

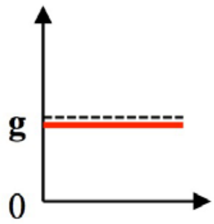
$$v_f = v_i + at$$

$$t = \frac{v_f - v_i}{a} = \frac{0 - 30cm/s}{-3.0cm/s^2} = 10s$$

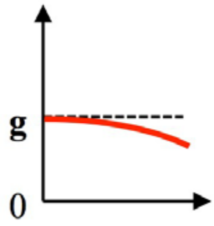
Question:

An object is dropped and accelerates downwards. As it falls it is affected by air friction, but never reaches terminal velocity during the course of its fall. The graph that could indicate the magnitude of the object's acceleration as a function of time is

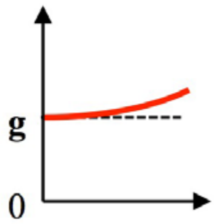
a.



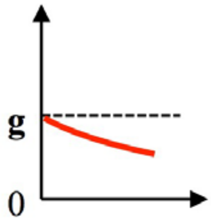
b.



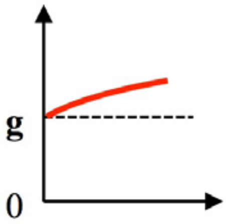
c.



d.



e.

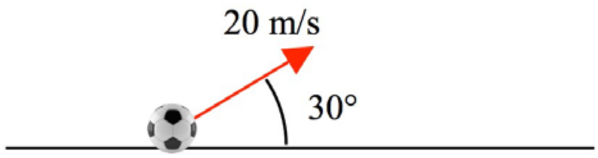


Answer:

The correct answer is ***d***. The falling object, when released from rest, has an initial acceleration of 9.8 m/s^2 (if near the surface of the earth). As its velocity increases, it collides with air molecules at an increasing rate, thus reducing the rate at which it accelerates. (The acceleration is usually modeled as a function of v or v^2, depending on a number of factors.) The acceleration continues to decrease until the acceleration of the object is 0, at which point the velocity of the falling object remains constant.

The only graph consistent with this analysis is *d*, where the acceleration curve can be seen to be approaching zero asymptotically.

Question:



A soccer ball is kicked to give it an initial velocity of 20 m/s at 30° relative to the ground, as shown. The maximum height reached by the ball will be about

a. 10 m
b. 1.0 m
c. 5.0 m
d. 20 m
e. 15 m

Answer:
The correct answer is *c*. To determine the vertical height reached by the ball, we focus only on the vertical aspects of the ball's motion.

The ball has an initial vertical velocity of 20 sin 30, or 10 m/s. The ball's final vertical velocity at the top of its path is 0 m/s. Using kinemati
can be determined:

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$\Delta y = \frac{v_f^2 - v_i^2}{2a} = \frac{0^2 - (10m/s)^2}{2(-10m/s^2)} = 5m$$

The ball has a horizontal aspect to its motion as well, of course—a horizontal velocity of 20 cos 30 = 17.3 m/s, and no acceleration—but these qualities are independent of the ball's vertical motion.

Question:

A student collects position-time data for an object moving along the *x*-axis, and determines that the motion corresponds closely with a mathematical model of $x = 1.5t^2 + 2.0t - 1.0$, where *x* is in meters and *t* is in seconds. Assuming that object moves according to this model, it can be determined that

a. at time $t = 0$, the object was at the origin
b. at time $t = 0$, the object had an initial velocity of 1.0 m/s
c. at time $t = 0$, the object had an initial acceleration of 1.5 m/s^2
d. during the motion, the acceleration of the object varied according to time-squared
e. none of these

Answer:

The correct answer is *e*. We can use the position-time function for the object to identify the objects position, velocity, and acceleration in a couple of different ways.

The calculus approach is based on the fact that $v = \frac{dx}{dt}$, and $a = \frac{d^2x}{dt^2}$, or $a = \frac{dv}{dt}$. Applying these relationships to the model, we see that

$$v = \frac{d}{dt}\left(1.5t^2 + 2t - 1\right) \qquad \text{and} \qquad a = \frac{d}{dt}(3t + 2)$$

$$v = 3t + 2 \qquad\qquad a = 3$$

By using $t = 0$ in the *x(t)*, *v(t)*, and *a(t)* equations we can see that none of the statements *a-d* are true. Instead, at time $t = 0$ the object has an intial position of -1.0 m, a velocity of 2.0 m/s, and an acceleration (constant throughout its motion) of 3.0 m/s^2.

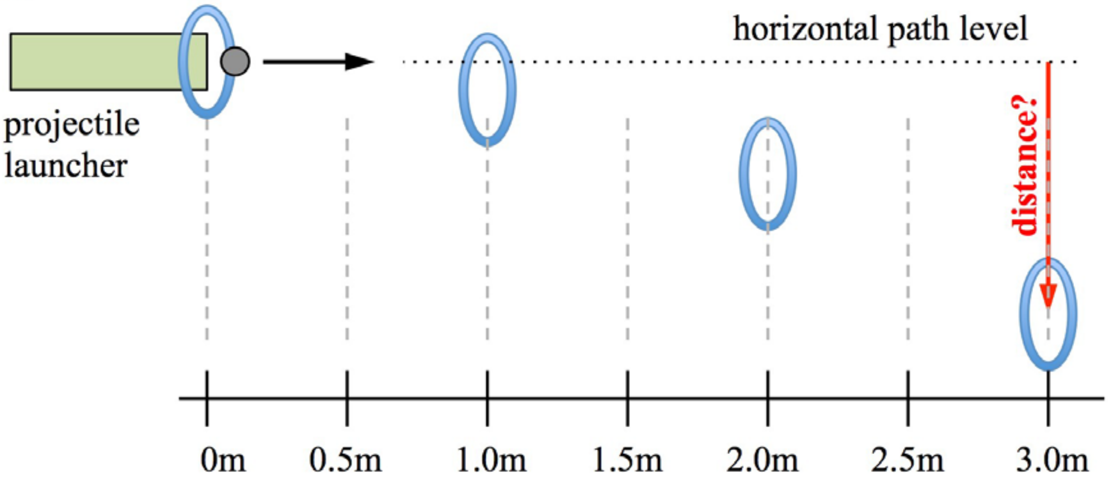
A non-calculus approach to solving this problem would consist of comparing the equation with the kinematics equation $x_f = x_i + v_i t + \frac{1}{2}at^2$. Rearrange this kinematics equation and compare it with the equation of the object's motion:

$$x_f = \frac{1}{2}at^2 + v_i t + x_i$$

$$x = 1.5t^2 + 2.0t - 1.0$$

Here we can clearly identify the same initial position, the initial velocity, and the acceleration of the object according to the terms and coefficients in the equations.

Question:



A physics teacher wants to prepare a demonstration on projectile motion for her students. A launcher, placed at the top of a building, will fire a ball horizontally, and the ball will pass through a series of elevated rings that have been set up as shown above. The ball is fired with an initial horizontal velocity of 2.0 m/s; air friction is negligible. At what distance below the horizontal path level should the fourth ring be placed if the ball is to pass through it?

a. 1.5 m
b. 3.0 m
c. 4.5 m
d. 6.0 m
e. 11 m

Answer:

The correct answer is *e*. A horizontal analysis of the ball reveals that it will reach ring 4 in 1.5 seconds:

$$\Delta x = v_x t$$

$$t = \frac{\Delta x}{v_x} = \frac{3.0m}{2.0m/s} = 1.5s$$

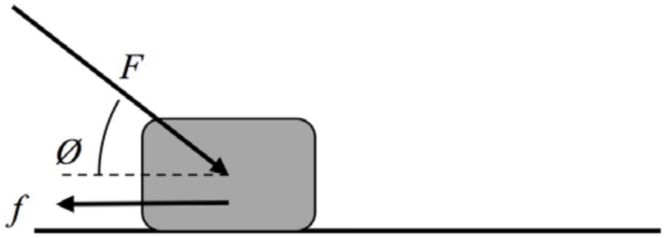
During that time, the vertical distance that the ball falls can be determined:

$$\Delta y = v_i t + \frac{1}{2}at^2$$

$$\Delta y = 0t + \frac{1}{2}(-10m/s^2)(1.5s)^2 = 5 \bullet 2.25 = -11m$$

You can also estimate the distance that the ball has traveled during the 1.5 seconds by using average velocity: the accelerating ball has an average velocity of 5m/s during its first second of travel. After one second of falling the ball will have dropped 5.0 meters. In the additional half-second of travel the ball will be moving even faster, making the 11 meter answer the logical result.

Question:



A block of mass *m* is pushed across a rough surface by an applied force *F*, directed at an angle Ø relative to the horizontal as shown above. The block experiences a friction force *f* in the opposite direction. What is the coefficient of friction between the block and the surface?

a. $\dfrac{mg}{F\sin\phi}$

b. $\dfrac{f}{F\sin\phi + mg}$

c. $\dfrac{f}{mg}$

d. $\dfrac{mg}{f}$

e. $\dfrac{f}{F\sin\phi - mg}$

Answer:

The correct answer is *b*. The key to finding the coefficient of friction μ is in calculating the correct Normal force acting on the block.

$$\sum F_y = ma$$

$$-F_{applied-y} - F_g + F_{Normal} = 0$$

$$F_{Normal} = F\sin\phi + mg$$

$$\mu = \frac{F_{friction}}{F_{Normal}} = \frac{f}{F\sin\phi + mg}$$

Question:

The planet Mars exerts a gravitational force F_{Mars} on its moon Phobos. Phobos, which has a smaller mass than Mars, also exerts a gravitational force F_{Phobos} on Mars. Which one of these statements is true?

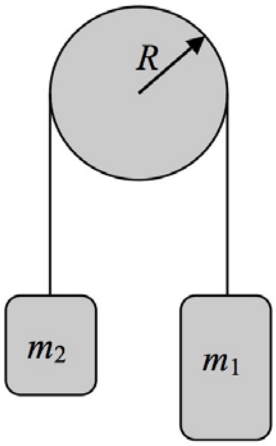
a. $F_{\text{Mars}} > F_{\text{Phobos}}$
b. $F_{\text{Phobos}} > F_{\text{Mars}}$
c. $F_{\text{Mars}} = F_{\text{Phobos}}$
d. Which one attracts more strongly depends on the distance between the two bodies.
e. Which one attracts more strongly depends on how close Mars's second moon, Deimos, is located.

Answer:

The correct answer is *c*. The force of gravitational attraction between any two masses is equal, and given by $F = G\frac{m_1 m_2}{r^2}$.

The magnitude of this force varies with distance *r*, of course, but at any given distance, the forces between the two bodies are equal. And while the presence of the second moon will affect the *net* force of gravitational attraction acting on a body, it doesn't change the force exerted by a different body.

Question:



Two masses are hung are connected by a light cord and hung from a frictionless pulley of negligible mass as shown. Mass m_1 = 3.00kg, and mass m_2 = 2.00kg. When the two masses are released from rest, the resulting acceleration of the two masses is approximately:

a. $1\ \mathrm{m/s^2}$
b. $2\ \mathrm{m/s^2}$
c. $4\ \mathrm{m/s^2}$
d. $6\ \mathrm{m/s^2}$
e. $8\ \mathrm{m/s^2}$

Answer:

The correct answer is *b*. This is a Newton's Second Law problem, using $F_{net} = ma$, where F_{net} = the net force acting on the pulley, and *m* refers to the total mass of the system.

$$F_{net} = ma$$

$$a = \frac{F_{net}}{m}$$

$$a = \frac{F_3 - F_2}{m}$$

$$a = \frac{3kg(\mathbf{g}) - 2kg(\mathbf{g})}{(2kg + 3kg)}$$

$$a = \frac{1}{5}\mathbf{g} \approx 2m/s^2$$

Question:

A block is pushed along a horizontal, frictionless surface, with a horizontal Force that varies as a function of time as shown in the graph here. At time $t = 3$ seconds, the acceleration of the block is 5.0 m/s^2. The mass of the block is

a. 1 kg
b. 2 kg
c. 3 kg
d. 5 kg
e. 15 kg

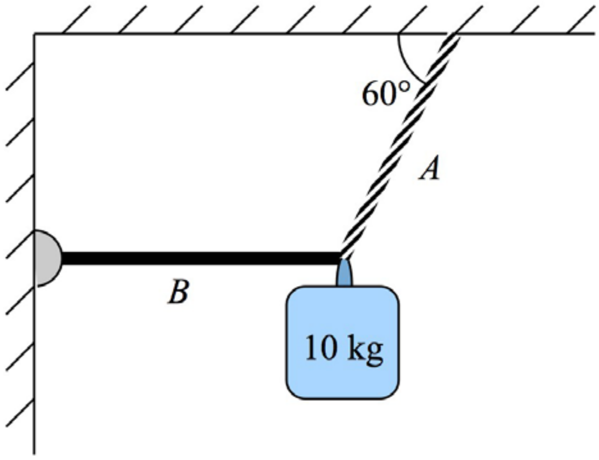
Answer:
The correct answer is *c*. The relationship between the force acting on the block, its mass, and acceleration is described by F=*m*a.

$$F_{net} = ma$$

$$15N = m(5m/s^2)$$

$$m = 3kg$$

Question:



A mass of 10 kg is suspended from a cable *A* and a light, rigid, horizontal bar *B* that is free to rotate, as shown. What is the approximate tension, in Newtons, in cable *A*?

a. $\frac{100}{\sqrt{3}}$

b. $100\sqrt{3}$

c. $\frac{200}{\sqrt{2}}$

d. $200\sqrt{3}$

e. $\frac{200}{\sqrt{3}}$

Answer:

The correct answer is *e*. The weight of the mass, approximately 100N, must be entirely supported by the vertical component of the tension in the cable, F_y. Therefore:

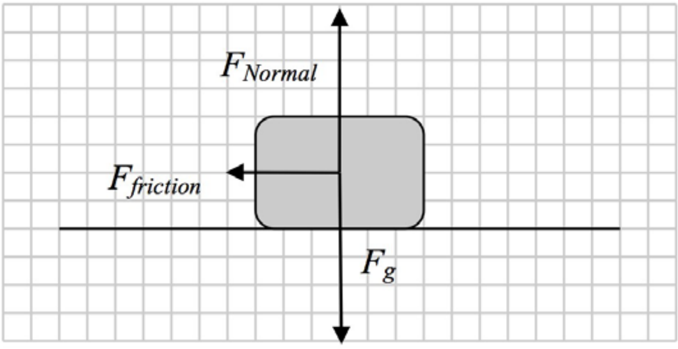
$$\sum F_y = ma$$

$$F_y - F_g = 0$$

$$F_y = F_{Tension} \sin 60 = (10kg)(\sim 10m/s^2)$$

$$F_{Tension} = \frac{100N}{\sqrt{3}/2} = 200/\sqrt{3}$$

Question:

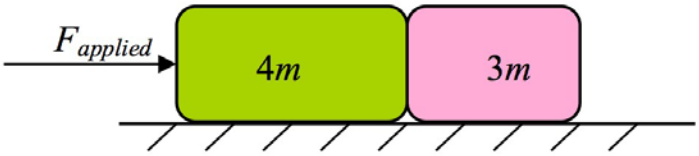


The free-body diagram shows all forces acting on a box supported by a stationary horizontal surface, where the length of each force vector is proportional to its magnitude. Which statement below is correct?

a. The box must be moving to the left, due to the Force of friction acting in that direction.
b. The box must be accelerating to the right, as indicated by the Force of friction in the opposite direction.
c. The box must be moving to the right, as indicated by the Force of friction in the opposite direction.
d. The diagram is drawn incorrectly: there can be no Force of friction unless the box is moving.
e. None of these statements is correct.

Answer:
The correct answer is *c*. The diagram suggests that the box is currently moving to the right, and in the process of slowing down due to a force of friction that is causing it to accelerate in the opposite direction (slowing down the box).

Question:



A Force F_{applied} is exerted on a pair of unconnected objects of mass 4*m* and 3*m*, resting on a frictionless horizontal surfce as shown above. What is the magnitude of the force between the two masses?

a. $F_{applied}$

b. $2F_{applied}$

c. $\frac{3}{4}F_{applied}$

d. $\frac{3}{7}F_{applied}$

e. $\frac{4}{7}F_{applied}$

Answer:

The correct answer is *d.* The problem can be solved by drawing two separate free-body diagrams and solving $F_{net} = ma$ for each body, then substituting and solving to get the required force. It's probably easier and faster, however, to solve $F_{net} = ma$ for the system as a whole to find acceleration...

$$F_{net} = ma$$

$$F_{applied} = (4m + 3m)a$$

$$a = \frac{F_{applied}}{7m}$$

...and then use this acceleration with the mass 3*m* to get the force acting between the masses:

$$F_{net} = ma$$

$$F_{on\ 3m\ from\ 4m} = (3m)\left(\frac{F_{applied}}{7m}\right)$$

$$F = \frac{3}{7}F_{applied}$$

Question:

Two masses, $M > m$, are connected by a light string hanging over a pulley of negligible mass. When the masses are released from rest, the magnitude of the acceleration of the masses is:

a. $\left(\frac{M+m}{M-m}\right)g$

b. $\left(\frac{M-m}{M+m}\right)g$

c. $\left(\frac{M}{M+m}\right)g$

d. $\left(\frac{m}{M+m}\right)g$

e. $\left(\frac{M-m}{M}\right)g$

Answer:

The correct answer is *b*. We can analyze this situation by drawing a picture and doing a free-body diagram for each of the two masses, as shown here. Because the pulley has negligible mass, the force of Tension between the two masses is equal (by Newton's 3rd Law), and we can use Newton's 2nd Law to determine the acceleration of the system:

$M: \quad F_{net} = ma = Ma$

$\quad Mg - F_{Tension} = Ma$ (where "down" is positive)

$m: \quad F_{net} = ma$

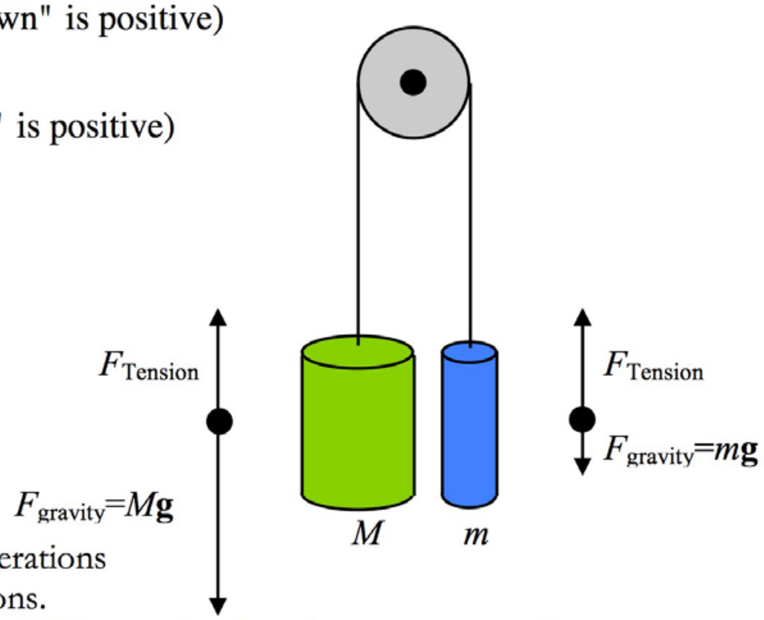
$\quad F_{Tension} - mg = ma$ (where "up" is positive)

Combine equations and solve:

$$Mg - (ma + mg) = Ma$$

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

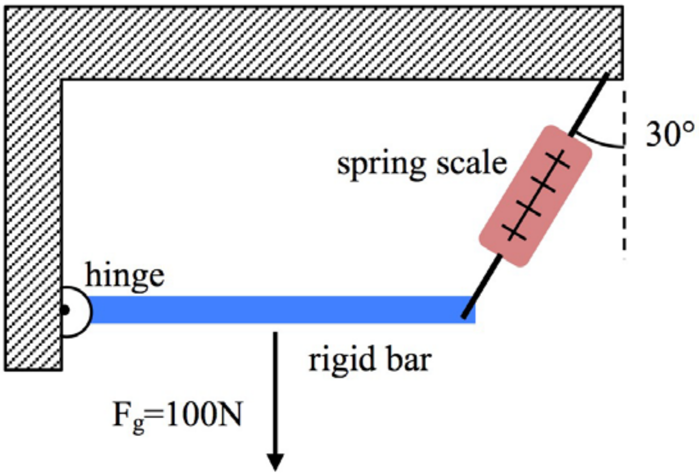
$$a = \left(\frac{M-m}{M+m}\right)g$$



Notice that we have selected different frames of reference for the two masses (for *m*, "up" is positive; for *M*, "down" is positive) so that the accelerations of the masses will have identical directions.

If we don't adjust our analysis to take the different directions into account, we'll get an incorrect result when we combine the two equations.

Question:



A rigid bar with a weight of 100 Newtons is free to rotate about a frictionless hinge at a wall, and supported in a horizontal position by a spring scale attached to the ceiling at an angle of 30° to the vertical, as shown. What force of tension is indicated by the spring scale?

a. $100\ N$
b. $100\sqrt{3}\ N$
c. $100/\sqrt{3}\ N$
d. $50/\sqrt{3}\ N$
e. $50\ N$

Answer:

The correct answer is *c*. The problem can be solved in two ways. The bar is being held in static equlibrium, so the sum of the torques acting on the bar has to be zero. Taking the hinge to be $x = 0$, one can add up the torque due to the force of gravity down (acting at the center of mass) and the torque due to the spring scale up.

More simply, the sum of the forces in the vertical direction has to be 0. Therefore:

$$\sum F_y = ma = 0$$

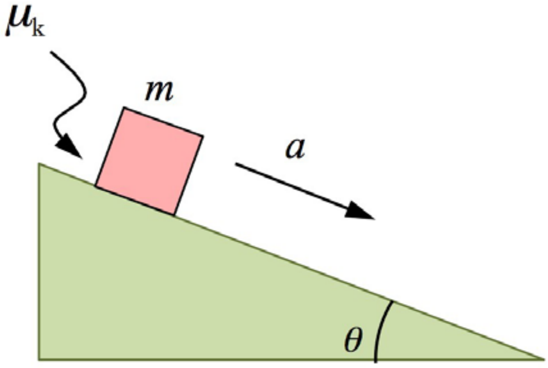
$$F_{hinge} - F_{gravity} + F_{y-springscale} = 0$$

Hinge and spring scale are equidistant from the center of mass, so each supports 50N.

$$F_{y-springscale} = 50N = F_{springscale}\cos 30$$

$$F_{springscale} = \frac{50}{\sqrt{3}/2} = \frac{100}{\sqrt{3}}N$$

Question:

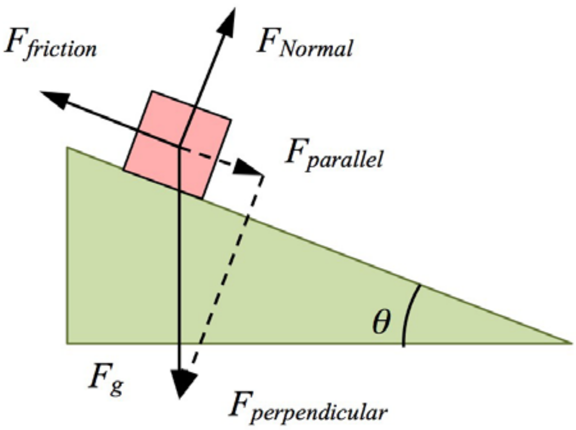


A block of mass m is placed on a plane inclined at an angle θ relative to the horizontal as shown. There is a coefficient of kinetic friction μ_k that acts as the block accelerates down the ramp. The acceleration of the mass m is

a. $mg\sin\theta - mg\cos\theta$
b. $mg\sin\theta - \mu mg\cos\theta$
c. $mg\sin\theta - \mu mg$
d. $g\sin\theta - g\cos\theta$
e. $g\sin\theta - \mu g\cos\theta$

Answer:

The correct answer is *e*. A free-body diagram of the forces acting on the block and an analysis using Newton's Second Law $F_{net} = ma$ yields the answer.



$$x - direction\ (down\ the\ ramp): F_{net} = ma$$

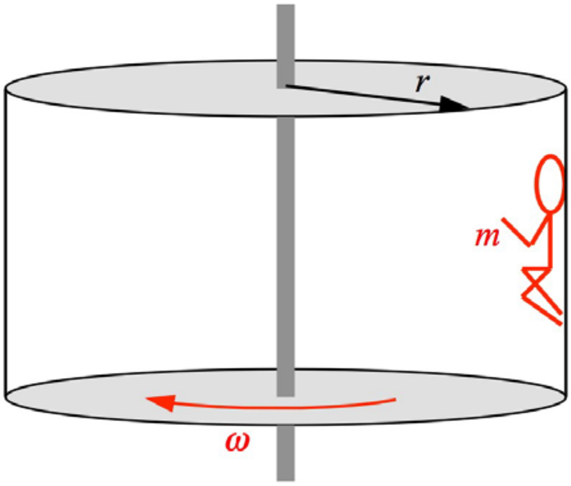
$$F_{parallel} - F_{friction} = ma$$

$$F_{friction} = \mu F_{Normal},\ and\ F_{Normal} = F_{perpendicular} = mg\cos\theta$$

$$mg\sin\theta - \mu mg\cos\theta = ma$$

$$a = g\sin\theta - \mu g\cos\theta$$

Question:



A ride at an amusement park consists of a hollow cylinder with a student placed against the wall as shown. When the cylinder rotates quickly enough, the student is able to lift her feet off the floor and remain stuck to the wall. In terms of the student's mass *m*, the radius of the cylinder *r*, the coefficient of static friction μ between the student and the wall, and fundamental quantities, determine the minimum rotational velocity ω that the ride can have while still allowing the student to stick to the wall and not slide down.

a. $\sqrt{\frac{g}{\mu r}}$ b. μmg c. $\sqrt{r\mu g}$ d. $\sqrt{\frac{\mu g}{r}}$ e. μrg

Answer:

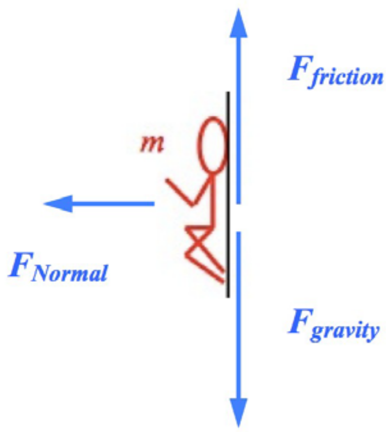
The correct answer is ***a***. A free-body analysis of the student against the wall of the cylinder shows that the friction Force *f* must be equal to the force of gravity *mg*, and that the normal force F_{Normal} acts as a centripetal force to keep the student moving in a circle.

Putting those pieces together, then:

$$\sum F_x = \frac{mv^2}{r} = F_N$$

$$\sum F_y = F_{friction} - F_{gravity} = 0,\ so\ F_f = mg$$

$$F_f = \mu F_N\ and\ v = r\omega$$



Solve to get:

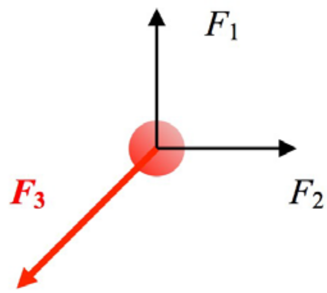
$$\omega = \sqrt{\frac{g}{\mu r}}$$

Question:

A mass *m* in three-dimensional space is subjected to three forces: F_1, F_2, and F_3. F_1 and F_2 have the same magnitude, with F_1 in the positive-*x* direction, and F_2 in the positive-*y* direction. If the mass has an acceleration of 0, which of the following statements is *false*?

a. The magnitude of F_3 is the same as that of F_1.
b. The object is in equilibrium, and could be stationary.
c. F_3 lies in the *x*-*y* plane.
d. The object is in equilibrium, and could be moving.
e. The object experiences a net force of 0.

Answer:



The correct answer is ***a***. By definition, the object is in equilibrium, either static (unmoving) or dynamic (moving with a constant velocity). If the object has acceleration $a = 0$, the net force acting on the mass must be 0 as well:

$$F_{net} = ma$$

$$F_{net} = m(0) = 0$$

With forces F_1 and F_2 in the *x*-*y* plane, the force that will counteract them must lie in the *x*-*y* plane as well, as shown. The magnitude of that force F_3 is equal to the vector sum of F_1 and F_2, and can be calculated as follows:

$$\sum F_x = 0 = \vec{F}_2 - \vec{F}_{3-x}$$

$$\sum F_y = 0 = \vec{F}_1 - \vec{F}_{3-y}$$

$$|F_3| = \sqrt{F_{3-x}{}^2 + F_{3-y}{}^2}$$

$$= \sqrt{F_1^2 + F_2^2}$$

$$= F_1\sqrt{2}$$

Both graphically and analytically, we can see that the magnitude of F_3 is not the same as that of F_1.