1. A block of mass m is moving to the right along a curved track as shown in the figure. Which of the following statements is correct regarding the work done by gravity, W_g, and the work done by the normal force on the block, W_N?

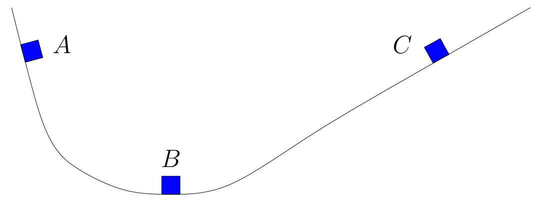
    (A) $W_g > 0$ and $W_N > 0$ from A to B;
    $W_g < 0$ and $W_N < 0$ from B to C

    (B) $W_g > 0$ and $W_N = 0$ from A to B;
    $W_g > 0$ and $W_N = 0$ from B to C

    (C) $W_g > 0$ and $W_N = 0$ from A to B;
    $W_g < 0$ and $W_N = 0$ from B to C

    (D) $W_g > 0$ and $W_N > 0$ from A to B;
    $W_g < 0$ and $W_N > 0$ from B to C

    (E) $W_g < 0$ and $W_N > 0$ from A to B;
    $W_g < 0$ and $W_N > 0$ from B to C



Answer LOs:
A:
B: 26
C: 23,26,32
D: 23
E:

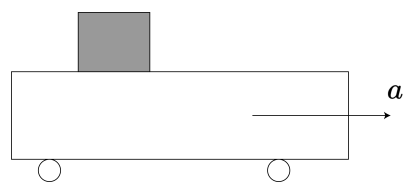
2. A box of mass 2 kg is placed on a cart that is initially at rest. At $t = 0$, the cart begings to accelerate with $a = 2$ m/s^2; the box moves with the cart without slipping. Over the first $\Delta t = 5$ s of the motion, what is the work, W, that the frictional force does on the box, and what is the average power P? Ignore air resistance.

    (A) $W = 0$, $P = 0$

    (B) $W = 100$ J, $P = 20$ J/s

    (C) $W = -100$ J, $P = -20$ J/s

    (D) $W = -100$ J, $P = -4$ J/s



Answer LOs:
A:
B: 21,27,29,32,33,34,39
C: 21,27,29,33,34,39
D: 27,29

3. A block of mass m and initial speed v is sliding down on an incline of angle θ. It moves distance d before it stops. How much work is done by the force of friction?

   (A) mgd

   (B) $-mgd\cos\theta - \frac{1}{2}mv^2$

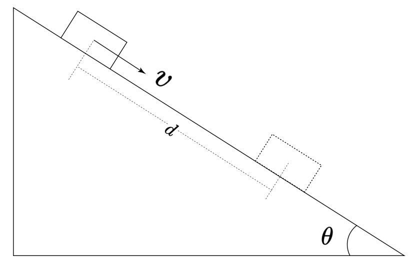
   (C) $mgd\sin\theta - \frac{1}{2}mv^2$

   (D) $-mgd\sin\theta$

   (E) $-mgd\sin\theta - \frac{1}{2}mv^2$

   (F) $mgd\cos\theta$

   (G) $mgd\cos\theta - \frac{1}{2}mv^2$



   Answer LOs:
   A:
   B: 28,32,34,39
   C: 1,34
   D: 1
   E: 1,28,32,34,39
   F:
   G: 34

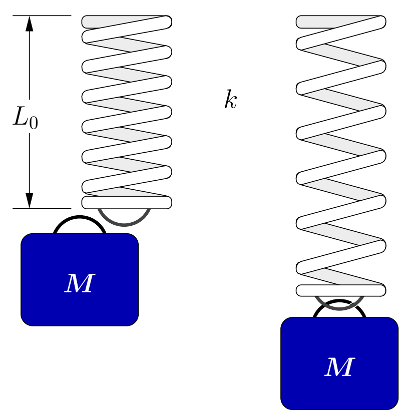
4. A block of mass M is attached to the end of a vertical spring with a force constant k. Initially, the block is held such that the spring is at it's unstretched length, L_0. When released from this position, the block falls due to the force of gravity. How much work has the spring done on the block in going from the initial height to the point where the net force on the block is zero? Ignore air resistance and friction.

   (A) $W = \frac{-1}{k}(Mg)^2$

   (B) $W = \frac{1}{2k}(Mg)^2$

   (C) $W = \frac{-1}{2k}(Mg)^2$

   (D) $W = \frac{-1}{4k}(Mg)^2$



   Answer LOs:
   A:
   B: 21,25,38,39
   C: 21,25,32,38,39
   D:

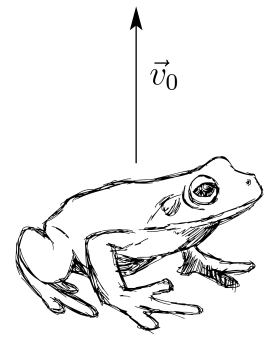
5. A frog of mass 0.5 kg jumps vertically upward with the initial velocity $\vec{v}_0 = (1.0 \text{ m/s})\hat{\jmath}$. Considering the highest point of the frog's jump, what are P_{ave} (the average power exerted by gravity on the frog from the start of the jump to its highest point) and P_{inst} (the instantaneous power exerted by gravity on the frog at the highest point). Ignore air resistance and approximate $g \approx 10 \text{ m/s}^2$.

   (A) $P_{\text{ave}} = -2.5$ W, $P_{\text{inst}} = 0$

   (B) $P_{\text{ave}} = 2.5$ W, $P_{\text{inst}} = 0$

   (C) $P_{\text{ave}} = -5.0$ W, $P_{\text{inst}} = 0$

   (D) $P_{\text{ave}} = -2.5$ W, $P_{\text{inst}} = -5.0$ W



Answer LOs:
A: 14,21,32,33,33
B: 14,33
C: 14,33
D: 21,33

6. A small rock with mass 0.12 kg is fastened to a massless string with length $L = 80$ cm to form a pendulum. The pendulum is swinging so as to make a maximum angle of $\theta_{\text{max}} = 60°$ with the vertical. What is the tension in the string when the string passes through the vertical position? (Neglect air resistance and take $g = 10 \text{ m/s}^2$.)

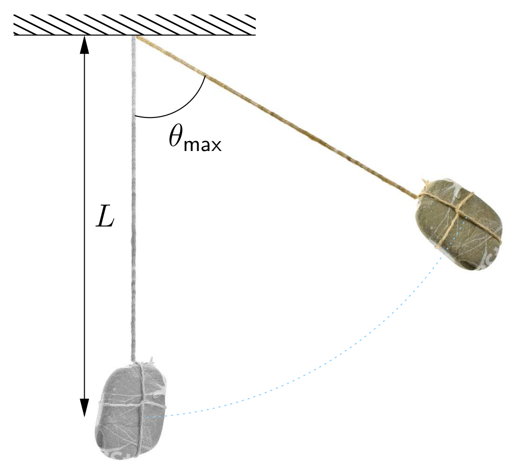
   (A) 1.2 N

   (B) 2.4 N

   (C) 3.3 N

   (D) 1.9 N

   (E) 1.5 N



Answer LOs:
A: 16,34,39,40
B: 16,21,24,34,39,40
C:
D:
E:

7. As shown in the figure, a small toy car of mass m is put in front of a spring of force constant k and which is compressed a distance Δx. After releasing the spring, the car is pushed along the track by the spring and enters a loop of radius R. The initial height of the car is $h = 2R$. What is the minimum value of Δx so that the ball makes the loop? (Neglect friction and treat the car as a point-like object. The gravitational acceleration is g.)

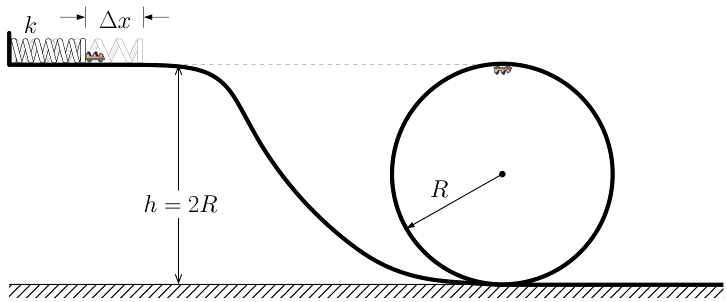
   (A) $\sqrt{mgR/2k}$

   (B) $\sqrt{mgR/k}$

   (C) $\sqrt{2mgR/k}$

   (D) $\sqrt{3mgR/k}$

   (E) $\sqrt{5mgR/k}$



Answer LOs:
A: 16,18,25,39,40,
B: 16,18,25,34,38,39,40
C: 16,18,25,39,40,
D:
E:

8. As shown in the figure, a block of mass m is attached in the end of a rope that is fastened on a rough horizontal plane. The block is in circular motion with an initial speed v_0. After the first round, its speed decreases to $\frac{1}{2}v_0$ from the constant force of friction. How many total rounds does it take before the block stops? (The mass of rope is negligible.)

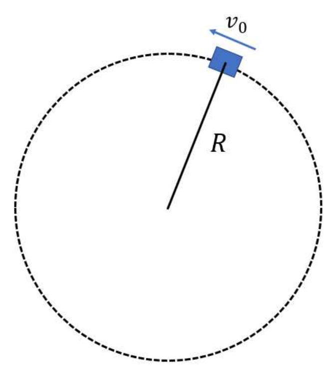
   (A) 3

   (B) $\frac{8}{3}$

   (C) 2

   (D) $\frac{5}{3}$

   (E) $\frac{4}{3}$



Answer LOs:
A:
B:
C:
D:
E: 28,39

9. A ball of mass 5.0 kg is suspended by two wires from a horizontal arm that is attached to a vertical shaft, with the dimensions as shown in the figure. The shaft is in uniform rotation about its axis with a period of $T = 5$ seconds. Find the tensions on wire 1 and 2. Assume $g = 10$ m/s^2 and $\pi^2 = 10$.

   (A) $T_1 = 14$ N and $T_2 = 36$ N

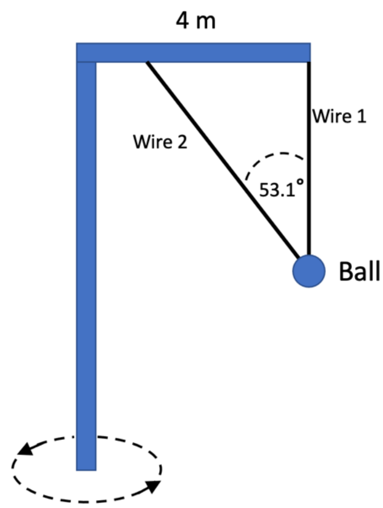
   (B) $T_1 = 26$ N and $T_2 = 40$ N

   (C) $T_1 = 22$ N and $T_2 = 44$ N

   (D) $T_1 = 20$ N and $T_2 = 48$ N

   (E) $T_1 = 7$ N and $T_2 = 53$ N

   Answer LOs:
   A:
   B: 1,4,18,19,22,23,24
   C:
   D:
   E: 4,18,19,22,23,24



10. Block A weighs 60 N and lies on a table. The coefficients of static and kinetic friction between block A and the table are 0.25 and 0.20, respectively. As shown, block A is connected with strings to a weight w. Find the maximum weight, w, such that the system remains in equilibrium.

   (A) 12 N

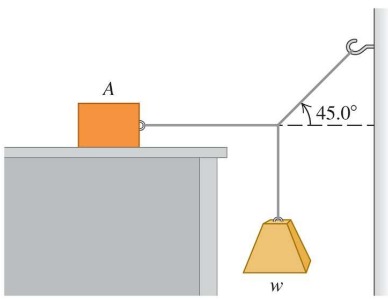
   (B) 15 N

   (C) 30 N

   (D) 60 N

   (E) 120 N

   Answer LOs:
   A: 1,21,23,24,26
   B: 1,21,23,24,26,27,29
   C:
   D:
   E:



11. A 25-kg box is being transported on the bed of a truck. The box is secured by straps pushing down on the box with a force of 150 N. The coefficient of static friction between the box and the bed of the truck is 0.25. What is the maximum acceleration the truck can take for which the box wouldn't slide under the straps? As always, take the acceleration of gravity to be $g = 10$ m/s^2.

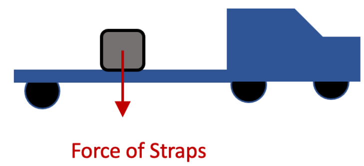
   (A) 1 m/s^2

   (B) 4 m/s^2

   (C) 8 m/s^2

   (D) 16 m/s^2

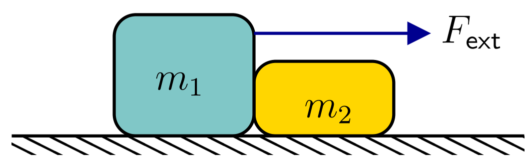
   (E) 32 m/s^2

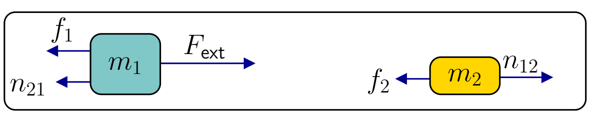


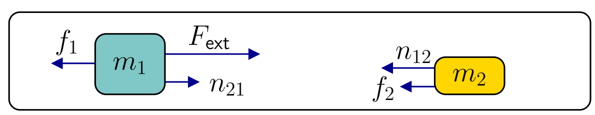
Answer LOs:

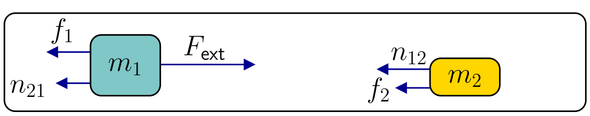
A:
B: 22,23,26,29
C:
D:
E:

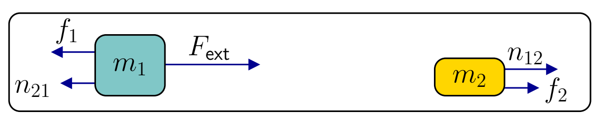
12. Two blocks are on a horizontal surface. The friction force between each individual block and the bottom surface is f_1 and f_2 respectively. There is an external horizontal force F_{ext} applied to the block on the left, which makes both blocks move towards the right as shown below. Considering only the forces acting on the horizontal direction, which of the following options shows the correct directions of the horizontal forces in the free-body diagrams for each block (*note*: the lengths of the arrows are not to scale).

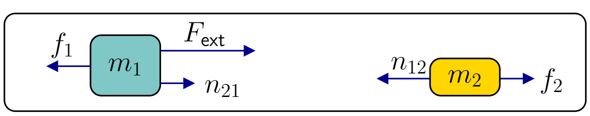


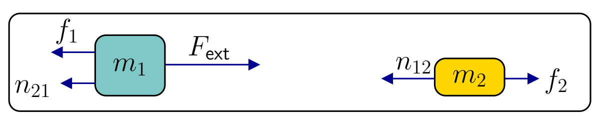
(A)


(B)


(C)


(D)


(E)


(F)


Answer LOs:

A: 22,26,28
B: 28
C: 28
D: 22,26
E:
F:

13. A block of mass m is moving with an initial velocity $\vec{v}_0$ on a slab of mass M in the positive $\hat{i}$ direction. The slab is initially at rest on the floor, which is smooth so there is no appreciable friction between the slab and the floor. Eventually, the block and the slab move together with the same velocity because of the friction between them. What is the impulse that the block of mass m imparts to the slab of mass M via the force of friction during this time?

(A) $Mv_0\hat{i}$

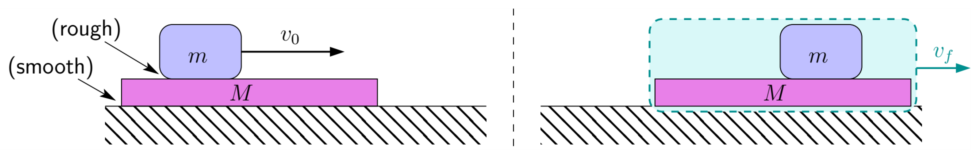
(B) $-mv_0\hat{i}$

(C) $\left(\frac{mM}{m+M}\right) v_0\hat{i}$

(D) $-\left(\frac{M^2}{m+M}\right) v_0\hat{i}$

(E) $mv_0\hat{i}$

(F) $\left(\frac{m}{m+M}\right) v_0\hat{i}$



Answer LOs:

A:
B:
C: 46,48,49
D:
E:
F: 48

14. A solid, uniform sphere is placed on top of a solid, uniform cylinder as shown below. The sphere and the cylinder have the same mass M and radius R. They are rotating around the axis shown as a solid line in the figure with the same angular velocity. What is the moment of inertia of the composite object, and does the sphere or cylinder have a larger rotational kinetic energy?

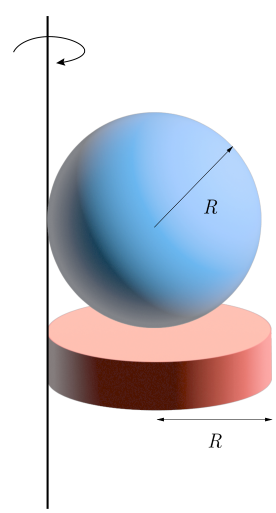
(A) $I_{\text{tot}} = 2MR^2$; the sphere and cylinder have the same rotational kinetic energy.

(B) $I_{\text{tot}} = \frac{9}{10}MR^2$; the sphere has more rotational kinetic energy.

(C) $I_{\text{tot}} = \frac{9}{10}MR^2$; the cylinder has more rotational kinetic energy.

(D) $I_{\text{tot}} = \frac{29}{10}MR^2$; the sphere has more rotational kinetic energy.

(E) $I_{\text{tot}} = \frac{29}{10}MR^2$; the cylinder has more rotational kinetic energy.



Answer LOs:

A:
B:
C: 35,35
D: 51,52,52
E: 35,35,51,52,52

15. A rock of mass $M = 7$ kg is at rest on a frictionless table. After smashed by a hammer with a force perpendicular to the table, it breaks into three pieces of masses $m_1 = 4$ kg, $m_2 = 1$ kg, and $m_3 = 2$ kg. The first piece is found to slide at velocity $v_1 = 0.1$ m/s in the direction $\theta = 36.9°$ east of north, while the second and third pieces are found to slide in the west and south directions, respectively. What are the speed of the second and third pieces?

(A) $v_2 = 0.12$ m/s, $v_3 = 0.08$ m/s

(B) $v_2 = 0.08$ m/s, $v_3 = 0.12$ m/s

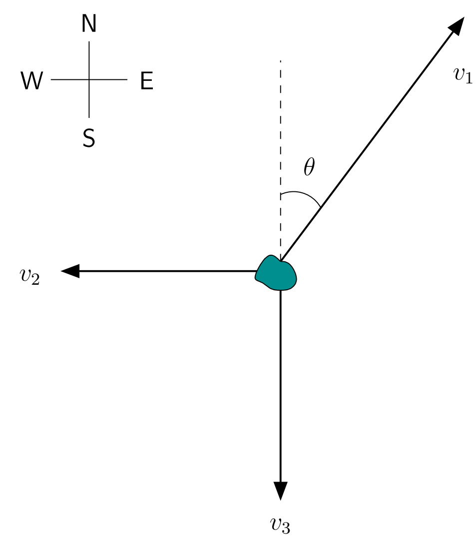
(C) $v_2 = 0.24$ m/s, $v_3 = 0.16$ m/s

(D) $v_2 = 0.16$ m/s, $v_3 = 0.24$ m/s

(E) $v_2 = 0.48$ m/s, $v_3 = 0.32$ m/s

(F) $v_2 = 0.32$ m/s, $v_3 = 0.48$ m/s

(G) $v_2 = 0.32$ m/s, $v_3 = 0.32$ m/s



(not to scale)

Answer LOs:

A:
B:
C: 1,3,3,4,46,46,48,48
D: 3,3,4,46,46,48,48
E:
F:
G:

16. Two blocks A and B are connected together through a pulley of mass $M_P = 30$ kg and radius $R = 10$ cm as shown in the figure. Block B, which has a mass $M_B = 300$ kg, is at a height of $h = 10$ m above the floor when the system is released from rest. If it takes $t = 2$ s for block B to reach the floor, find: the mass, M_A, of block A; the tension, T_B, on the rope holding block B; and the angular velocity of the pulley, ω_P, when block B reaches the floor. Assume that the rope doesn't stretch, never slips over the pulley, and that the acceleration due to gravity is $g = 10$ m/s^2 downward.

(A) $T_B = 1500$ N, $M_A = \ 95$ kg, $\omega_P = 100$ rad/s

(B) $T_B = 1500$ N, $M_A = \ 95$ kg, $\omega_P = 1$ rad/s

(C) $T_B = 1500$ N, $M_A = 100$ kg, $\omega_P = 100$ rad/s

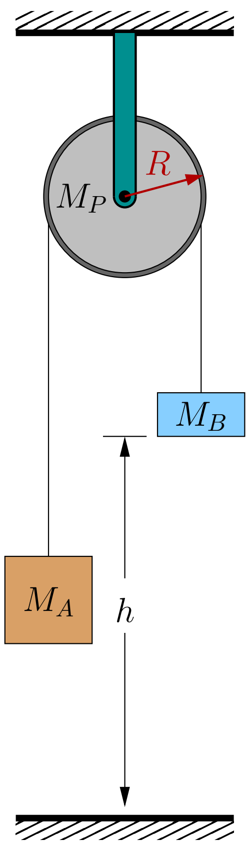
(D) $T_B = 3000$ N, $M_A = 100$ kg, $\omega_P = 1$ rad/s

(E) $T_B = 4500$ N, $M_A = 150$ kg, $\omega_P = 10$ rad/s

(F) $T_B = 4500$ N, $M_A = 200$ kg, $\omega_P = 20$ rad/s

(G) $T_B = 6000$ N, $M_A = 150$ kg, $\omega_P = 20$ rad/s

(H) $T_B = 6000$ N, $M_A = 200$ kg, $\omega_P = 40$ rad/s



Answer LOs:

A: 4,10,12,14,21,23,24,34,35,38,51
B: 4,12,14,21,23,24,34,35,38,51
C: 4,12,14,21,23,24,34
D: 4,10,12,14,23,24,35
E:
F:
G:
H:

17. A block of 5 kg is moving to the right with a speed of 10 m/s at the bottom part of a smooth hill (there is no friction between the blocks and the surface). Before climbing the hill the block hits a second block of 5 kg initially at rest. The two blocks collide, stick together, and climb the hill. Find the maximum height that the system of two blocks climb up the hill. Assume $g = 10$ m/s^2.

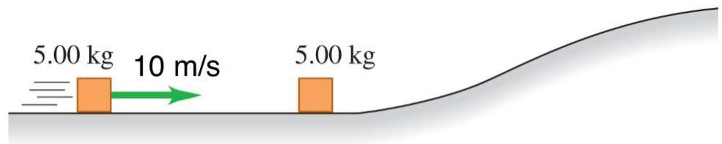
    (A) $h = 5/4$ m

    (B) $h = 5/2$ m

    (C) $h = 5$ m

    (D) $h = 10$ m

    (E) $h = 20$ m



Answer LOs:
A: 34,38,39,40,46,48
B:
C: 34,38,39,40
D:
E:

18. A long, uniform rod of length L and mass M is pivoted about a horizontal, frictionless pin passing through one end. The rod is released from rest in a vertical position, as shown in the Figure. At the instant the rod is horizontal, find its angular speed ω.

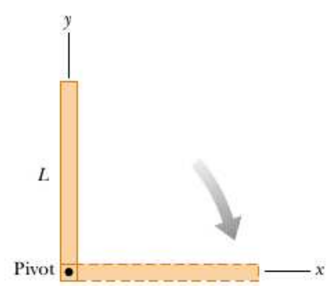
    (A) $\omega = \sqrt{\frac{2g}{L}}$

    (B) $\omega = \sqrt{\frac{3g}{L}}$

    (C) $\omega = \sqrt{\frac{12g}{L}}$

    (D) $\omega = \sqrt{\frac{g}{2L}}$

    (E) $\omega = \sqrt{\frac{3g}{2L}}$



Answer LOs:
A:
B: 35,38,39,40,51
C: 35,38,39,40
D:
E: 38,51