1. (6 points) A small plane flies horizontally with a kinetic energy of 1.8×10^6 J under the influence of the vertical forces of weight and lift force, and horizontal forces of thrust and air resistance. The power of the thrust force is a constant 120 kW. Atmospheric disturbances change only the force of air resistance during 60 seconds of flight. If the kinetic energy of the plane after the disturbance is half of the initial value, find the work done by the air resistance W_{air} during the disturbance.

   (A) $W_{air} = -8.1 \times 10^6$ J

   (B) $W_{air} = -6.3 \times 10^6$ J

   (C) $W_{air} = -7.2 \times 10^6$ J

   (D) $W_{air} = +8.1 \times 10^6$ J

   (E) $W_{air} = +6.3 \times 10^6$ J

   (F) $W_{air} = +7.2 \times 10^6$ J

   (G) $W_{air} = -4.4 \times 10^6$ J

   (H) $W_{air} = +4.4 \times 10^6$ J

   Points Per Response:

   A: 6
   B: 4
   C:
   D: 4
   E: 3
   F:
   G:
   H:

2. (6 points) A block of mass m is on a horizontal table with friction μ_k, under the presence of gravity, g. Applying only a force in the horizontal plane, Ricardo moves the block on a closed path over the table at constant speed, v_0. Knowing that the total length of the closed path is ℓ compute the work done by Ricardo.

   (A) $W_{\text{Ricardo}} = +\mu_k mg\ell$

   (B) $W_{\text{Ricardo}} = -\mu_k mg\ell$

   (C) $W_{\text{Ricardo}} = 0$

   (D) $W_{\text{Ricardo}} = +\frac{1}{2}mv_0^2$

   (E) $W_{\text{Ricardo}} = -\frac{1}{2}mv_0^2$

   (F) $W_{\text{Ricardo}} = +\frac{1}{2}mv_0^2 + \mu_k mg\ell$

   (G) $W_{\text{Ricardo}} = -\frac{1}{2}mv_0^2 - \mu_k mg\ell$

   Points Per Response:

   A: 6
   B: 4
   C:
   D:
   E:
   F: 2
   G: 1

3. (8 points) A block is moving horizontally with velocity $v_0 = +2.00$ m/s when it enters a rough, horizontal section with coefficient of friction that depends on position as $\mu_k = 1.60x$ where $x = 0$ is the location where the block first encounters the friction force. At what position will the block will come to rest?

   (A) $x = +0.505$ m

   (B) $x = +0.128$ m

   (C) $x = -0.505$ m

   (D) $x = -0.128$ m

   (E) $x = +0.411$ m

   (F) $x = -0.411$ m

   (G) $x = +0.706$ m

   (H) $x = -0.706$ m

Points Per Response:

A: 8
B: 5
C: 5
D: 2
E:
F:
G:
H:

4. (8 points) A toy car with a mass of 200 g has a small motor that results in a constant net force F straight forward. The car is on the kitchen table that is 75.0 cm above the ground. If the car starts from rest 60.0 cm from the edge of the table, what does F have to be so that the car hits the floor 25.0 cm from the edge of the table?

   (A) 0.0681 N

   (B) 0.340 N

   (C) 0.941 N

   (D) 4.70 N

   (E) 1.10 N

   (F) 3.46 N

   (G) 2.06 N

   (H) 0.593 N

   Points Per Response:
   A: 8
   B: 6
   C: 6
   D: 4
   E:
   F:
   G:
   H:

5. (6 points) Two blocks are placed on a frictionless, horizontal surface as shown below where the top block has a mass of $m_A = 2.00$ kg and the bottom block has a mass of $m_B = 5.00$ kg. There is friction between the blocks of $\mu_s = 0.550$ and $\mu_k = 0.140$. A string is tied to the lower block and pulled with a force of 31.5 N. If the two blocks do not slide relative to each other, what is the magnitude of the friction force between the blocks?

   (A) 9.00 N

   (B) 10.8 N

   (C) 37.7 N

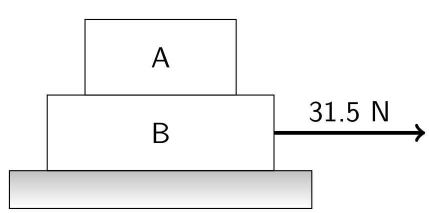
   (D) 27.0 N

   (E) 22.5 N

   (F) 2.74 N

   (G) 4.46 N

   (H) 19.1 N



   Points Per Response:
   A: 6
   B: 4
   C: 2
   D: 2
   E:
   F:
   G:
   H:

6. (4 points) Two blocks are in contact on a flat, frictionless surface. Block A is then pushed to the right by a force F. The boxes then move with a constant acceleration. Correctly rank the relationships between the forces.

(A) $F > F_{\text{A on B}} = F_{\text{B on A}}$

(B) $F > F_{\text{A on B}} > F_{\text{B on A}}$

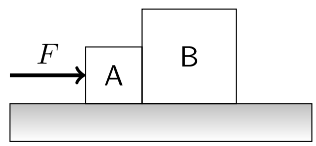
(C) $F = F_{\text{A on B}} > F_{\text{B on A}}$

(D) $F < F_{\text{A on B}} < F_{\text{B on A}}$

(E) $F = F_{\text{A on B}} < F_{\text{B on A}}$

(F) $F < F_{\text{A on B}} = F_{\text{B on A}}$

(G) $F = F_{\text{A on B}} = F_{\text{B on A}}$



Points Per Response:
A: 4
B:
C:
D:
E:
F: 1
G: 1

7. (8 points) Two blocks with masses M_1 and M_2 are connected by a massless cord passing over a massless, frictionless pulley and they are on inclined planes at angles of α_1 and α_2 respectively. Assume that the coefficients of kinetic and static friction between the blocks and the planes are approximately equal ($\mu_k = \mu_s = \mu$). Which condition below would cause the blocks to move to the left if released from rest?

(A) $M_1 (\sin\alpha_1 - \mu\cos\alpha_1) > M_2 (\sin\alpha_2 + \mu\cos\alpha_2)$

(B) $M_1 (\sin\alpha_1 + \mu\cos\alpha_1) > M_2 (\sin\alpha_2 + \mu\cos\alpha_2)$

(C) $M_1 (\sin\alpha_1 - \mu\cos\alpha_1) > M_2 (\sin\alpha_2 - \mu\cos\alpha_2)$

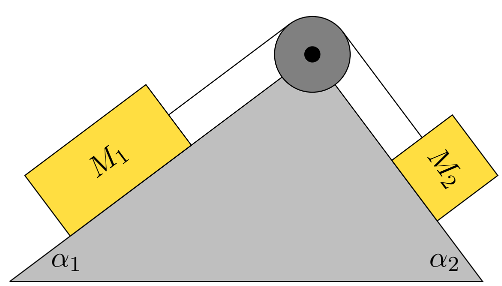
(D) $M_1 (\sin\alpha_1 + \mu\cos\alpha_1) > M_2 (\sin\alpha_2 - \mu\cos\alpha_2)$

(E) $M_1 \sin\alpha_1 > M_2 \sin\alpha_2$

(F) $M_1 \cos\alpha_1 > M_2 \cos\alpha_2$

(G) $M_1 > M_2$

(H) $\alpha_1 > \alpha_2$



Points Per Response:
A: 8
B:
C: 6
D:
E:
F:
G:
H:

8. (4 points) You have invented a special spring that has a potential energy function given by $U(x) = -0.1x^3 + 0.6x^2$ where all variables are given in SI units. There are two equilibrium points for this spring at $x = 0$ and $x = 4$. Identify whether these two points are stable or unstable equilibrium points.

   (A) $x = 0$ is a stable equilibrium point and $x = 4$ is an unstable equilibrium point.

   (B) $x = 0$ is an unstable equilibrium point and $x = 4$ is a stable equilibrium point.

   (C) Both positions are stable equilibrium points.

   (D) Both positions are unstable equilibrium points.

   Points Per Response:
   A: 4
   B:
   C:
   D:

9. (6 points) A massless ring has three massless ropes attched to it as shown in the figure below. There is a 400-kg box hanging from rope C which is in static equilibrium. Rope A is attached at $\theta = 30.0$ degrees from vertical, Rope B is perfectly horizontal and Rope C is perfectly vertical. What is the tension in Rope B?

   (A) 2260 N

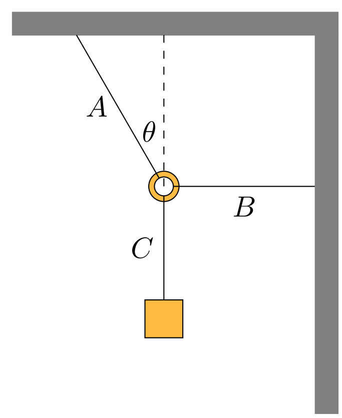
   (B) 4530 N

   (C) 3920 N

   (D) 1350 N

   (E) 5560 N

   (F) 6750 N



   Points Per Response:
   A: 6
   B: 3
   C: 2
   D:
   E:
   F:

10. (8 points) In the figure below there is a surface S and two blocks A and B. The mass of block A is equal to the mass of block B. Block B is held in place by a cable. There is a coefficient of kinetic friction between A and B as well as A and S that is equal to μ_k. What is μ_k if Block A slides at constant speed?

    (A) 0.444

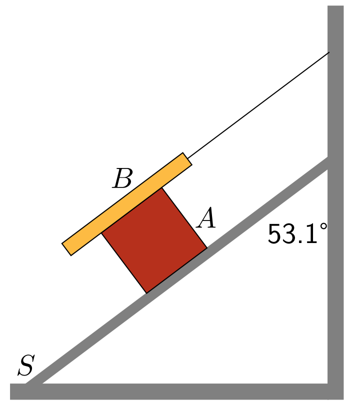
    (B) 0.666

    (C) 0.250

    (D) 0.375

    (E) 0.145

    (F) 0.741



Points Per Response:

A: 6
B: 6
C: 8
D: 4
E:
F:

11. (6 points) In the figure below there is a ball that is moving in a circular path with a constant speed and is attached to the ceiling with a massless cable. The angle of the cable holding the pendulum to the ceiling is 30.0 degrees from the vertical. What is the centripetal acceleration of the pendulum?

    (A) 5.66 m/s^2

    (B) 8.49 m/s^2

    (C) 4.90 m/s^2

    (D) 9.80 m/s^2

    (E) 17.0 m/s^2

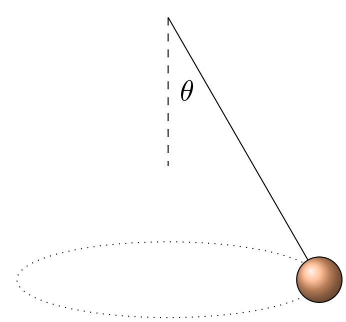
    (F) 7.46 m/s^2

    (G) 6.89 m/s^2

    (H) 3.44 m/s^2

Points Per Response:

A: 6
B: 3
C: 3
D:
E: 4
F:
G:
H:



12. (4 points) In the figure below a small ball of mass m is attached to a massless string. When the ball is released from rest at point A it will fall with radius ℓ, pivoting around a nail and then when it reaches vertical it will travel with a radius L. Which of the following properties will determine the tension at the bottom of the arc, just before reaching point B?

    (A) m

    (B) ℓ

    (C) L

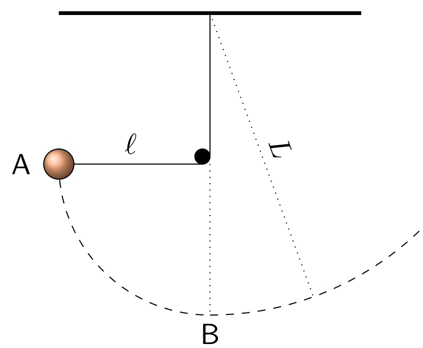
    (D) m and ℓ

    (E) m and L

    (F) ℓ and L

    (G) m, ℓ and L

    Points Per Response:
    A: 4
    B:
    C:
    D: 2
    E: 1
    F:
    G: 1



13. (4 points) The figure below is a side view of the motion of a heavy box that is being moved through the air. Which path will have the largest magnitude of work done by gravity?

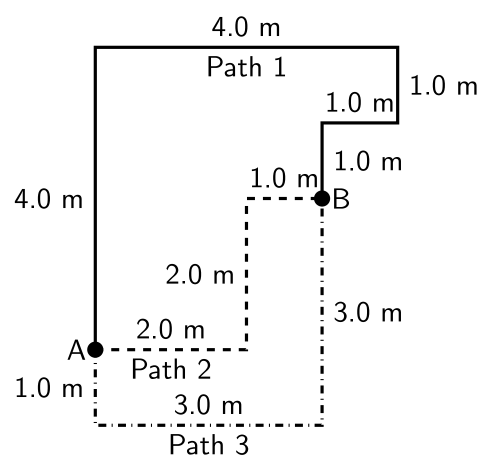
    (A) Path 1

    (B) Path 2

    (C) Path 3

    (D) All three will be the same

    Points Per Response:
    A:
    B:
    C:
    D: 4



14. (6 points) A box is sliding down a rough inclined plane at constant velocity. What is the correct relationship between the magnitude of the forces where F_g is the force due to gravity, F_N is the normal force and F_f is the force due to friction? Assume the angle of the incline plane is greater than 45 degrees ($\theta > 45°$).

(A) $F_g > F_f > F_N$

(B) $F_g > F_N > F_f$

(C) $F_f > F_g > F_N$

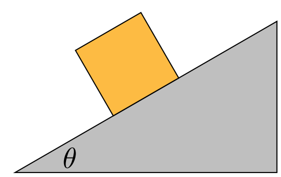
(D) $F_f > F_N > F_g$

(E) $F_N > F_f > F_g$

(F) $F_N > F_g > F_f$

Points Per Response:

A: 6
B: 3
C:
D:
E:
F:



15. (8 points) In the figure below, a block of mass 5.00 kg is sliding down from the top of a hill with an initial speed of 6.00 m/s. The hill is smooth, but the horizontal section has a coefficient of kinetic and static friction of 0.200 and 0.800, respectively. The force constant of the spring is 20.0 N/m. How far does the spring get compressed?

(A) 4.21 m

(B) 4.67 m

(C) 3.12 m

(D) 2.49 m

(E) 3.58 m

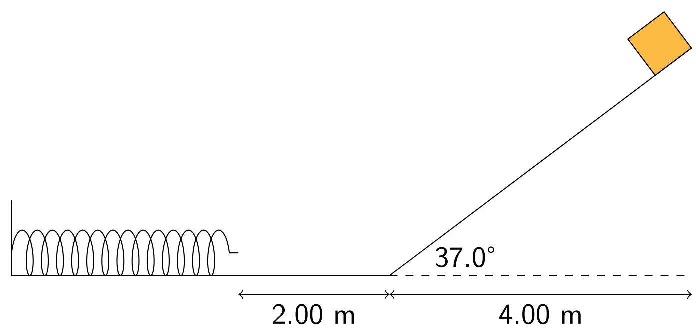
(F) 1.65 m

(G) 5.39 m

(H) 5.06 m

Points Per Response:

A: 8
B: 5
C: 5
D: 5
E: 2
F:
G:
H:



16. (4 points) If you were to complete the previous problem again, except the incline had a horizontal distance of 6.00 m instead, what would happen to the amount the spring compresses? Assume all other values stayed the same.

(A) The spring would compress more

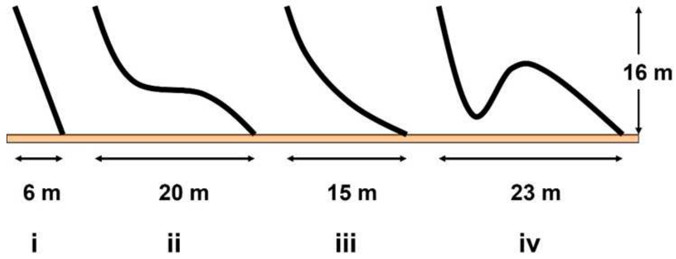
(B) The spring would compress less

(C) The spring would compress the same amount

Points Per Response:

A: 4
B:
C:

17. (4 points) Four boxes with different masses are going to slide down four frictionless slopes shown below. Rank the slopes from fastest speed at the bottom to slowest speed. The masses are: $m_i = 50$ kg, $m_{ii} = 25$ kg, $m_{iii} = 30$ kg and $m_{iv} = 25$ kg.



(A) $v_i = v_{ii} = v_{iii} = v_{iv}$

(B) $v_i > v_{ii} > v_{iii} > v_{iv}$

(C) $v_{iv} > v_{iii} > v_{ii} > v_i$

(D) $v_{iv} > v_{ii} > v_{iii} > v_i$

(E) $v_i > v_{iii} > v_{ii} > v_{iv}$

(F) $v_i > v_{iii} > v_{ii} = v_{iv}$

(G) $v_i > v_{iii} > v_{iv} > v_{ii}$

Points Per Response:

A: 4
B:
C:
D:
E:
F:
G: