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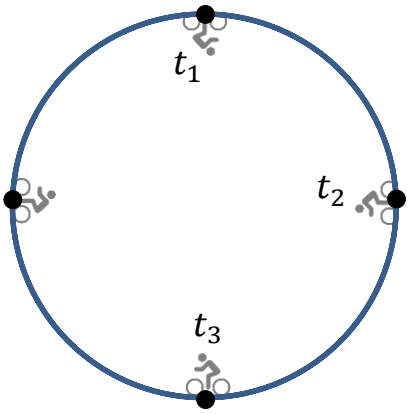
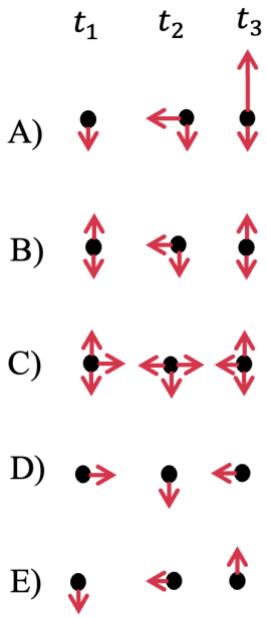
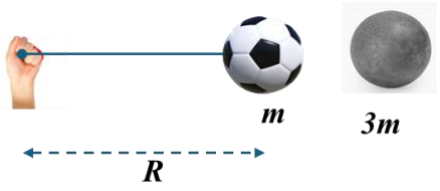
1. [5 pts] A cyclist is going clockwise around a vertical circular track (loop-the-loop). They are going just fast enough at the top to make it all the way around the track. The person is not pedaling. Ignore friction and drag. Which of the choices below (A to E) correctly shows the free-body diagrams for the cyclist at times t_1, t_2, and t_3?





2. [5 pts] A professor swings a soccer ball around in a horizontal plane at a constant angular frequency. The mass of the ball is $m = 0.45$ kg and the distance from the hand to the center of the ball is $R = 0.75$ m. The maximum angular frequency before the string breaks is $\omega = 8.0$ rad/s. If the ball is replaced by a solid sphere 3 times the mass of the soccer ball, what is the maximum angular frequency it can be rotated before the string breaks?



A) 0.89 rad/s

B) 2.7 rad/s

C) 4.6 rad/s

D) 8.2 rad/s

E) 24 rad/s

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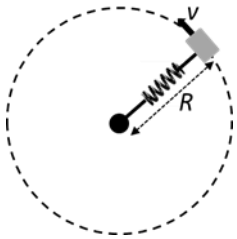
3. [5 pts] A 30-kg block is rotating on a frictionless *horizontal* surface at a constant speed of 3.0 m/s. A spring (k = 250 N/m) attaches the center pivot of the circle to the block as shown. The spring is expanded from its equilibrium length by 0.60 m. What is the length of the unstretched spring?



Top-view diagram

A) 0.6 m
B) 1.0 m
C) 1.2 m
D) 1.5 m
E) 1.8 m

4. [5 pts] Complete the following sentence. "The work done to accelerate a car from 0 to 30 m/s ……"

A) is more than that required to accelerate it from 30 m/s to 60 m/s.
B) is equal to that required to accelerate it from 30 m/s to 60 m/s.
C) is less than that required to accelerate it from 30 m/s to 60 m/s.
D) The sentence can be completed by any of the preceding statements, depending on the time taken.
E) None of the above statements correctly complete the sentence.

5. [5 pts] What is the work done by a car's braking system when it slows the 1500-kg car from an initial speed of 96.0 km/h to 56.0 km/h in a distance of 55.0 m?

A) -8.30 kJ
B) -352 kJ
C) -816 kJ
D) -1270 kJ
E) -4560 kJ

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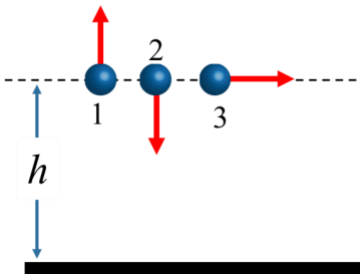
6. [5 pts] Three balls of equal mass are fired simultaneously **with equal speeds** from the same height h above the ground. Ball 1 is fired straight up, ball 2 is fired straight down, and ball 3 is fired horizontally. Rank in order from largest to smallest their speeds v_1, v_2, and v_3 just before each ball hits the ground. Ignore air resistance.



A) $v_1 > v_2 > v_3$

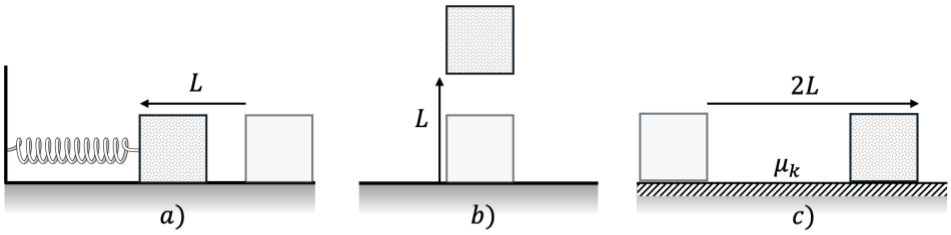
B) $v_3 > v_2 > v_1$

C) $v_2 > v_3 > v_1$

D) $v_1 = v_2 > v_3$

E) $v_1 = v_2 = v_3$

7. [5 pts] Three situations are shown where a block of mass m is moved by an external force from an initial rest position to a final rest position. In a) it compresses a spring a distance L from its equilibrium length; in b) the block is raised a distance L from the ground; in c) it is pushed a distance $2L$ across a rough surface. Parameters: $\boldsymbol{m}$ **= 5 kg**; $\boldsymbol{k}$ **= 327 N/m**; μ_k**= 0.5**; and $\boldsymbol{L}$ **= 0.3 m.**



Rank the work done on the system by the external force for the three cases. The system is defined in the diagram.

A) $W_a > W_b > W_c$

B) $W_a > W_c > W_b$

C) $W_b > W_a > W_c$

D) $W_b > W_c > W_a$

E) $W_a = W_b = W_c$

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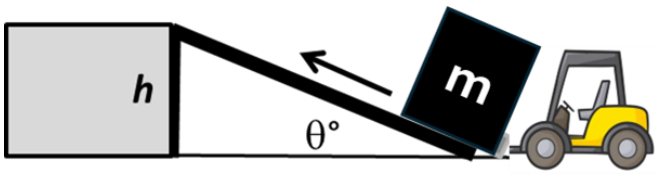
8. [5 pts] A forklift pushes a box up a ramp at a constant speed, raising it a vertical distance $\boldsymbol{h}$. The box has mass $\boldsymbol{m}$ and the coefficient of kinetic friction between the box and the ramp is $\boldsymbol{\mu_k}$. Calculate the work done by the forklift on the box-ramp-Earth system to push the box to the top of the platform. The ramp is at an incline angle of θ.



A) mgh

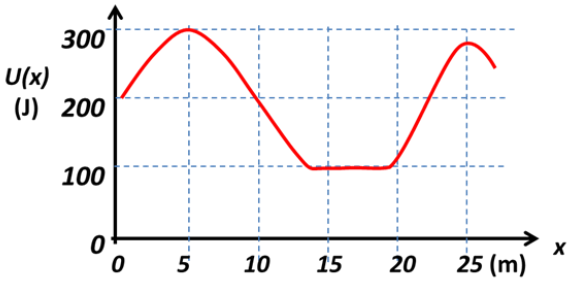
B) $mgh\mu_k \frac{\sin\theta}{\cos\theta}$

C) $mgh\mu_k \frac{\cos\theta}{\sin\theta}$

D) $mgh\left(1+\mu_k \frac{\cos\theta}{\sin\theta}\right)$

E) $mgh\tan\theta$

9. [5 pts] The potential energy curve for a system that contains a single particle is shown at right. Rank the force on the particle, from most negative to most positive, when the particle is $\boldsymbol{x}$ **= 5 m, 10 m, 22 m, and 25 m.**



A) $F_5 < F_{10} < F_{22} < F_{25}$

B) $F_{22} < F_5 = F_{25} < F_{10}$

C) $F_{22} < F_{10} < F_{25} < F_5$

D) $F_{10} < F_{22} < F_5 = F_{25}$

E) $F_{10} < F_5 = F_{25} < F_{22}$

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Lab Multiple Choice Questions

10. [5 pts] A group of students measure the time it takes a coffee filter to fall 1.5 m. The data is shown at right. They calculate the uncertainty in the three readings using the **standard deviation** of their measurements. How could they report the average time and its uncertainty correctly according to the guidelines in the Phys 121 labs?

Trial	Time (s)
1	1.13
2	1.17
3	1.11

$$\sigma = \sqrt{\frac{\sum_{i=0}^{N}(x_i - \bar{x})^2}{N-1}}$$

A) (1.14 ± 0.03) s

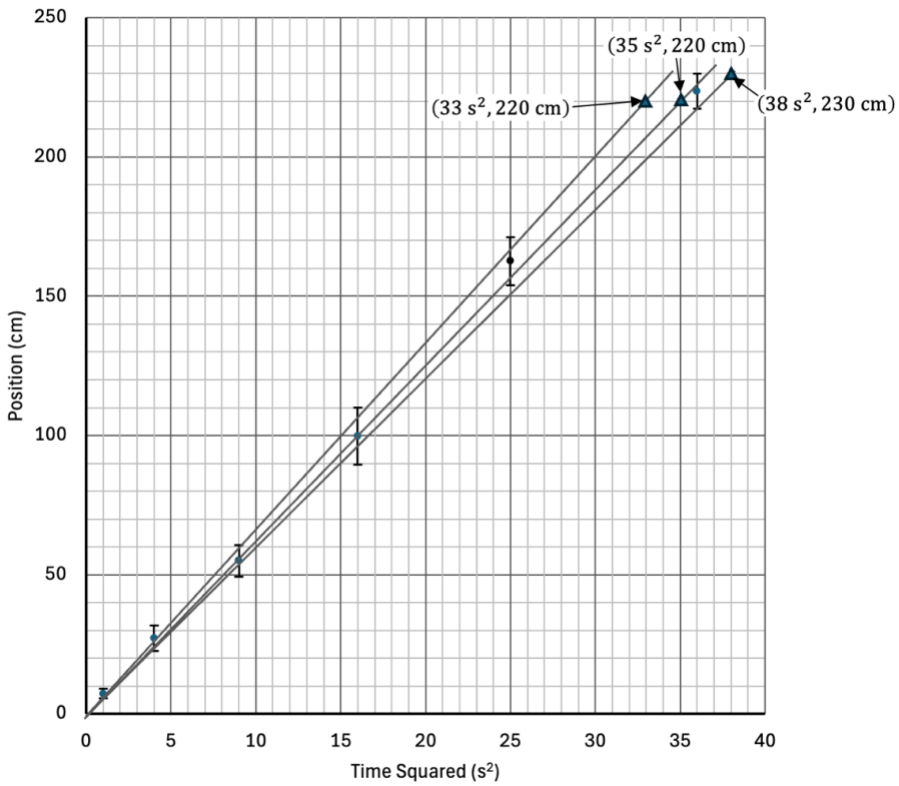
B) (1.14 ± 0.05) s

C) (1.137 ± 0.041) s

D) (1.15 ± 0.03) s

E) (1.172 ± 0.025) s

11. [5 pts] A group of students have carried out Lab B1 and B2, and they form the x vs. t^2 graph shown below. The graph also includes lines of best-fit, maximum slope and minimum slope. All lines pass through the origin and a second coordinate (triangle markers) for each line is shown on the graph. **Based on the concepts outlined in these labs**, how should the students correctly report the acceleration of the ball?



A) (6.285 ± 0.381) cm/s^2

B) (6.29 ± 0.38) cm/s^2

C) (8.92 ± 0.85) cm/s^2

D) (12.57 ± 0.76) cm/s^2

E) (12.8 ± 0.9) cm/s^2

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12. [5 pts] A student is trying to determine the terminal speed of a coffee filter using distance and time data. The distance the coffee filter falls through while moving at terminal speed is (1.650 ± 0.005) m, and the time taken to fall this distance is (1.12 ± 0.08) s. **Based on the guidelines from Lab C1**, how could they report the terminal speed correctly?

A) (1.473 ± 0.105) m/s

B) (1.47 ± 0.11) m/s

C) (1.51 ± 0.09) m/s

D) (1.5 ± 0.2) m/s

E) (1.49 ± 0.11) m/s

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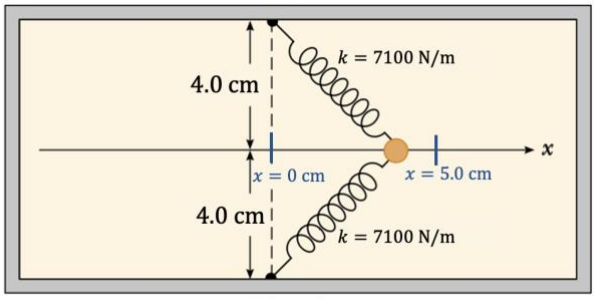
Lecture Free Response

The following two questions are about this scenario. A ball is attached between two identical springs on a horizontal frictionless table. Both springs have spring constant $k = 7100$ N/m. The ball is initially at rest at $x = 0.0$ cm and the springs each have an equilibrium length of 4.0 cm. The ball is then moved by an external force to $x = 5.0$ cm where it is held at rest. **Show your work for all questions.**



Top view

13. [5 pts] How much work do the springs do on the ball while the ball is being moved from $x = 0$ to $x = 5.0$ cm?

14. [5 pts] What is the net force of both springs on the ball when the ball is at $x = 5$ cm?

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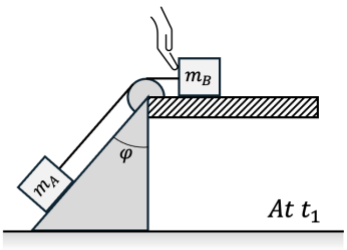
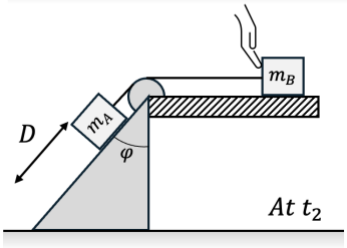
$Q15$ to $Q17$ refer to this scenario. Two blocks, A and B, with masses m_A and m_B are attached by a massless rope that goes around a massless and frictionless pulley. Block A is on a frictionless slope with angle φ from the vertical and block B is on a rough surface with a coefficient of kinetic friction μ_k. The blocks are initially held at rest. **Show your work for all questions.**

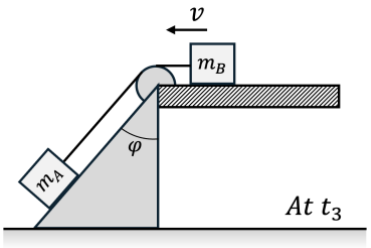


15. [5 pts] At t_1, a hand pushes block B to the right such that block A travels a distance D up the ramp. At t_2, both blocks are at rest. Consider a system that includes the Earth, the two blocks and all surfaces in the diagram. In terms of the given variables, what is the change in the gravitational potential energy of this system between t_1 and t_2?



16. [5 pts] Consider a system that includes the Earth, the two blocks and all surfaces in the diagram. In terms of the given variables, what is the change in thermal energy of this system between t_1 and t_2?

17. [5 pts] The hand then releases the blocks. At time t_3, block B has moved a distance D to the left and is moving at a speed v. Consider a system that includes both blocks and all surfaces shown. What is the change in the energy of this system between t_1 and t_3 (so, including both the periods from t_1 to t_2 and from t_2 to t_3)?



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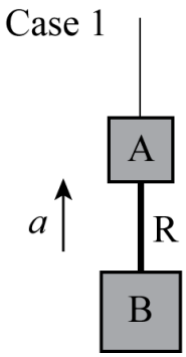
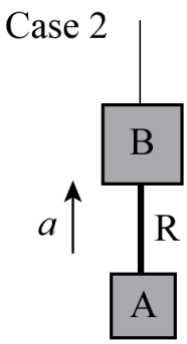
Tutorial Free Response Questions

18. [5 pts] In case 1, blocks A and B ($m_A < m_B$) are connected by a rope (R) of mass m. A string is connected to block A, and the entire system is pulled upward such that the system accelerates upward. Is the magnitude of the tension force exerted by block A on the rope *greater than, less than,* or *equal to* the magnitude of the tension force that block B exerts on the rope? Explain.



19. [5 pts] In case 2, the order of the blocks is reversed, such that the bottom of the rope is attached to block A as shown. The blocks are pulled upward with the same acceleration as in case 1. Is the magnitude of the tension force that block B exerts on the rope in case 2 *greater than, less than,* or *equal to* the magnitude of the force that block A exerts on the rope in case 1? Explain.



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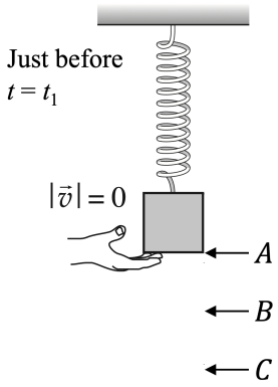
20. [5 pts] A spring and block are hung from a ceiling as shown. The block is initially held at position *A,* and the spring is neither stretched nor compressed. The block is released at time t_1. It reaches its maximum speed at point *B* at time t_2, and it turns around at point *C* at time t_3.



Over the interval from t_2 to t_3 (*i.e.,* as the block moves from *B* and *C*), is the absolute value of the work on the block by the spring *greater than, less than,* or *equal to* the absolute value of the work on the block by the Earth? Explain.