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# Center for Academic Resources in Engineering (CARE) Mid-Semester Review Session

**Phys211 – University Physics: Mechanics**

**Midterm 2 Worksheet**

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*The problems in this review are designed to help prepare you for your upcoming exam. Questions pertain to material covered in the course and are intended to reflect the topics likely to appear in the exam. Keep in mind that this worksheet was created by CARE tutors, and while it is thorough, it is not comprehensive. In addition to exam review sessions, CARE also hosts regularly scheduled tutoring hours.*

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Tutors are available to answer questions, review problems, and help you feel prepared for your exam during these times:

Session 1: Sun. 10/19, from 6:00-7:50pm Alex, Diego, Lucas

Session 2: Mon. 10/20, from 7:00-8:50pm Nico, Andy, Teddy

Can't make it to a session? Here's our schedule by course:

https://care.grainger.illinois.edu/tutoring/schedule-by-subject

Solutions will be available on our website after the last review session that we host.

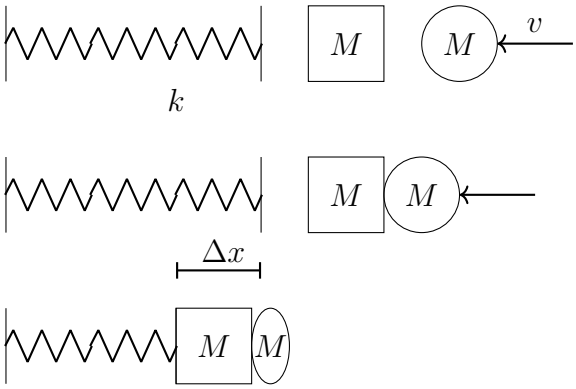
Step-by-step login for exam review session:

1. Log into Queue @ Illinois: https://queue.illinois.edu/q/queue/847
2. Click "New Question"
3. Add your NetID and Name
4. Press "Add to Queue"

**Please be sure to follow the above steps to add yourself to the Queue.**

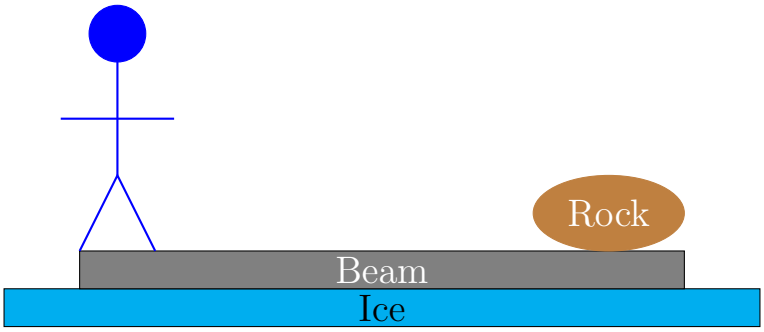
Good luck with your exam!

1. A putty ball of mass $M = 4$ kg is traveling horizontally at $v = 7$ m/s. (Ignore the effects of gravity). It strikes a block of the same mass, which is adjacent to a relaxed ideal spring attached to an infinitely massive wall with a spring constant of $k = 8$ N/m. The putty ball sticks to the block. After the collision, the spring is compressed.




What is the maximum compression of the spring?

2. A very strong man is standing at one end of a beam of length $L = 23$ m. The man has mass $M_{man} = 120$ kg and the beam has mass $M_{beam} = 59$ kg and the beam is atop a frictionless sheet of ice. At the other end of the beam sits a large rock of mass $M_{rock} = 251$ kg.

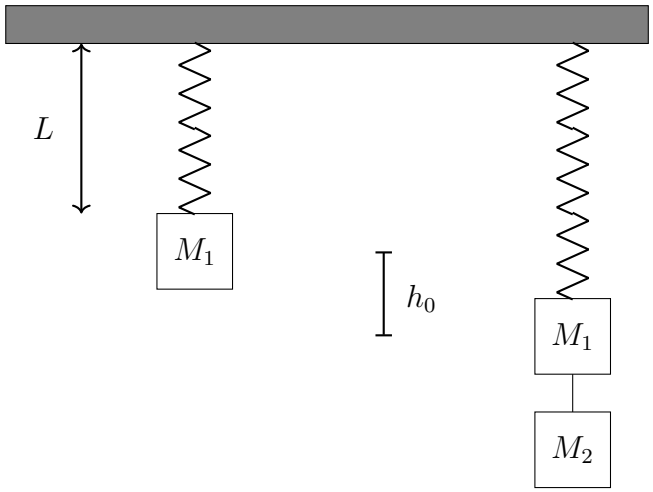



(a) The man walks to the other end of the beam and sits down on the rock. How far did the beam move along the ice?

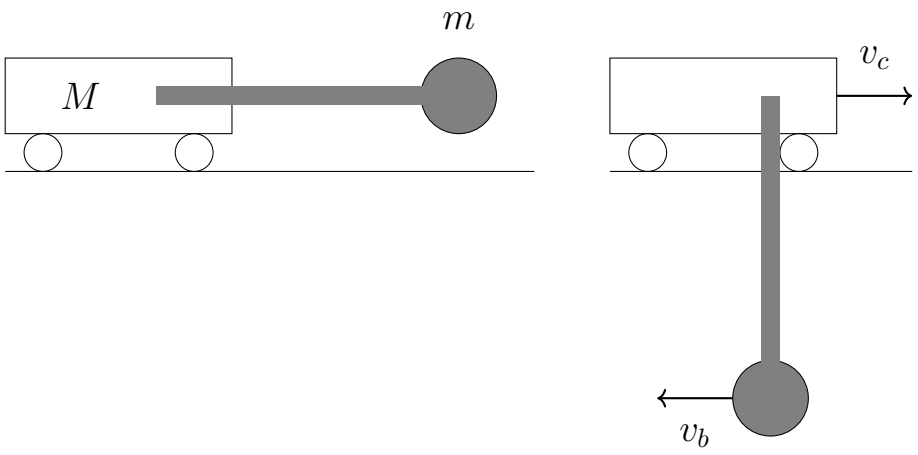
(b) True or False? As the man walks, the momentum of the beam+man+rock system is not conserved because the man is exerting a force on the beam.

(c) Suppose the man throws the rock off the beam with some velocity $v = 2$ m/s in the $+\hat{\mathbf{x}}$ direction to the right. What is the final velocity of the man who is still standing on the beam?

3. A block of mass $m_1 = 15$ kg hangs from the ceiling on an ideal, massless spring with spring constant $k = 60$ N/m. With the block hanging on the spring, the total length of the spring is $L = 4.5$ m. When a second block with an identical mass of $m_2 = 15$ kg is tied to the first with a massless string, the spring stretches an additional $h_0 = 2.45$ m. The string is cut so that mass $m_2$ falls away. What is the maximum velocity of mass $m_1$?



4. A cart of mass $M = 8$ kg rolls without friction on a horizontal surface. It is attached at the cart's center of mass to a freely pivoting initially-horizontal massless rod of length L to a ball of mass $m = 4$ kg. The system is initially at rest when the ball is released. The pendulum swings down and to the left, and at the bottom of its swing the ball is observed to have a $v_b = 3$ m/s to the left.




(i) Which one of the following remains constant as the pendulum swings down?

A) horizontal component of the momentum of the ball

B) horizontal component of the momentum of the cart

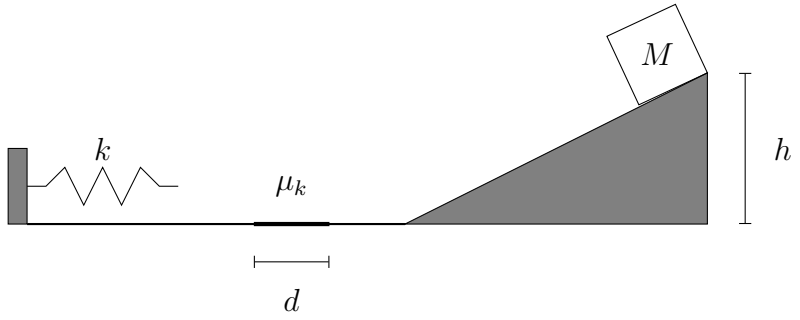
C) horizontal component of the momentum of the ball + cart

(ii) What is the speed of the cart when the ball is at the bottom?

(iii) What is the length L of the pendulum?

(iv) How far to the right has the cart moved, when the ball is at the bottom (in terms of L)?

5. A block of mass $M = 2.0$ kg is released from rest $h = 1.5$ meters above the ground and slides down a frictionless ramp. It slides across a floor that is frictionless, except for a small section with width $d$ =0.5 meters that has a coefficient of kinetic friction $\mu_k = 0.5$. At the left end, is a spring with spring constant $k = 300$ N/m. The box compresses the spring, and is accelerated back to the right.



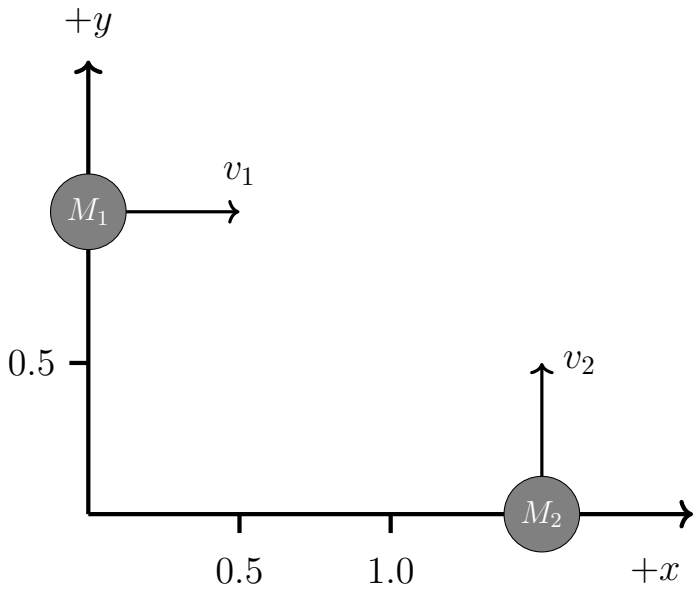

(a) What is the speed of the box at the bottom of the ramp?

(b) What is the maximum distance the spring is compressed by the box?

(c) What is the maximum height to which the box returns on the ramp?

6. Two discs are free to move without friction on a horizontal table. Disc $M_1 = 10.4$ kg and is initially at the position (x = 0, y = 1.0) m, moving with velocity $v_1 = (v_x = 3.0, v_y = 0)$ m/s. Disc $M_2 = 10.6$ kg and is initially at (x = 1.5, y = 0) m, moving with velocity $v_2 = (v_x = 0, v_y = 2.0)$ m/s. The figure below displays the initial conditions for the two discs in the x-, y- coordinates.

(i) The initial velocity of the center of mass of the two-disc system is:




A) $(v_x, v_y) = (3.12, 2.12)$ m/s

B) $(v_x, v_y) = (2.12, 3.12)$ m/s

C) $(v_x, v_y) = (1.51, 0.99)$ m/s

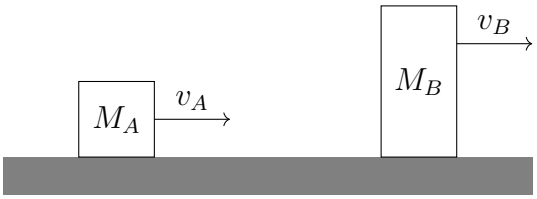
D) $(v_x, v_y) = (2.50, 2.50)$ m/s

E) $(v_x, v_y) = (1.48, 1.01)$m/s

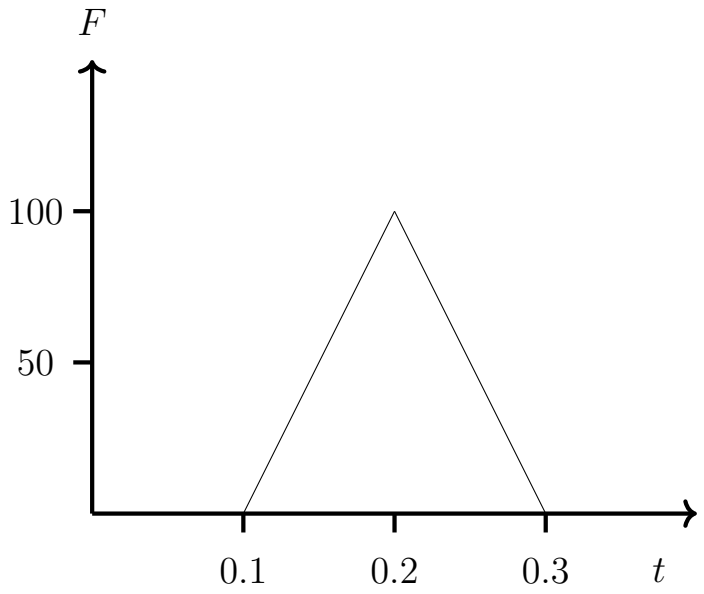
(ii) The two discs are allowed to collide elastically. Given that the velocity of the 10.6 kg disc is $(v_x, v_y)$ = (1.4, 1.2) m/s after the collision, what is the velocity of the 10.4 kg disc?

A) (2.3, 1.2) m/s
B) (1.2, 1.4) m/s
C) (1.6, 0.8) m/s
D) (1.4, 1.2) m/s
E) (0.8, 1.6) m/s

7. Two blocks $A$ and $B$ are on a path to collide with each other. $M_A = 10$ kg and $v_A = 30$ m/s to the right while $M_B = 30$ kg and $v_B = 10$ m/s to the right. What is the velocity of each in the center of mass frame?



8. A ball of mass $M = 2$ kg is moving left at constant velocity $v =$ -3 m/s when it hits a wall. The force applied by the wall onto the ball is plotted against time as shown below. What is velocity of the ball after hitting the wall?




9. During an explosion, a single particle at rest splits into two smaller particles both of mass $m = 5$ kg. The total chemical energy released is 270 J. What is the final speed each of particle and the total momentum of the the whole system?