Exam 1: Thursday, 2/20, 8:20-10:10pm

- **Room Assignments:**

Last Name	Room
A-G	NRN 137
H-O	TUR L007
P-Z	CLB C130

- **Breakdown of the 20 Problems**

Material	# of Problems
Chapter 1	0, but?
Chapter 2	4
Chapter 3	4
Chapter 4	4
Chapter 5	4
Chapter 6	4

- **Crib Sheet:** You may bring a single hand written formula sheet on 8½ x 11 inch paper (both sides).
- **Calculator:** You should bring a calculator (any type, no wifi).
- **Scratch Paper:** We will provide scratch paper.

Exam 1: Thursday, 2/20, 8:20-10:10pm

- **Room Assignments:**
- **Breakdown of the 20 Problems**
- **Crib Sheet:**
- **Calculator:**
- **Scratch Paper:**

The exams are difficult!
We have to find out who is good
at problem solving and who is not.
Expect an average of ~12/20
with high = 20 and low = 2!

Exam 1 Fall 2010: Problem 4

- A motorist drives along a straight road at a constant speed of 80 m/s. Just as she passes a parked motorcycle police officer, the officer takes off after her at a constant acceleration. If the officer maintains this constant value of acceleration, what is the speed of the police officer when he reaches the motorist?

Answer: 160 m/s
% Right: 18%

$$a_{car} = 0 \qquad a_{cop} = a$$
$$v_{car}(t) = v_0 \qquad v_{cop}(t) = at$$
$$x_{car}(t) = v_0 t \qquad x_{cop}(t) = \tfrac{1}{2}at^2$$

Let t_c be the time it takes for officer to reach the motorist.

$$x_{car}(t_c) = x_{cop}(t_c)$$
$$v_0 t_c = \tfrac{1}{2}at_c^2 \qquad t_c = \frac{2v_0}{a}$$
$$v_{cop}(t_c) = at_c = a\left(\frac{2v_0}{a}\right) = 2v_0$$
$$= 2(80m/s) = 160m/s$$

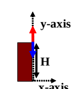
Final Exam Fall 2011: Problem 7

- Near the surface of the Earth a suspension bridge is a height H above the level base of a gorge. Two identical stones are simultaneously thrown from the bridge. One stone is thrown straight down with speed v_0 and the other is thrown straight up a the same speed v_0. Ignore air resistance. If one of the stones lands at the bottom of the gorge 2 seconds before the other, what is the speed v_0 (in m/s)?

Answer: 9.8
% Right: 36%

$$y_{up}(t) = H + v_o t - \tfrac{1}{2}gt^2 \qquad y_{down}(t) = H - v_o t - \tfrac{1}{2}gt^2$$
$$y_{up}(t_{up}) = 0 = H + v_o t_{up} - \tfrac{1}{2}gt_{up}^2 \qquad y_{down}(t_{down}) = 0 = H - v_o t_{down} - \tfrac{1}{2}gt_{down}^2$$

$$v_o t_{up} = \tfrac{1}{2}gt_{up}^2 - H$$
$$v_o t_{down} = -\tfrac{1}{2}gt_{down}^2 + H$$
$$v_0(t_{up} + t_{down}) = \tfrac{1}{2}g(t_{up}^2 - t_{down}^2)$$



$$v_0 = \tfrac{1}{2}g\frac{(t_{up}^2 - t_{down}^2)}{(t_{up} + t_{down})} = \tfrac{1}{2}g(t_{up} - t_{down}) = \tfrac{1}{2}(9.8m/s^2)(2s) = 9.8m/s$$

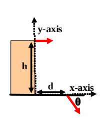
Exam 1 Spring 2012: Problem 12

- A beanbag is thrown horizontally from a dorm room window a height h above the ground. It hits the ground a horizontal distance d = h/2 from the dorm directly below the window from which it was thrown. Ignoring air resistance, find the direction of the beanbag's velocity just before impact.

Answer: 76.0° below the horizontal
% Right: 22%

$$v_x(t) = v_0 \qquad v_y(t) = -gt$$
$$x(t) = v_0 t \qquad y(t) = h - \tfrac{1}{2}gt^2$$

$$t_h^2 = \frac{2h}{g} \qquad v_0 = \frac{d}{t_h}$$

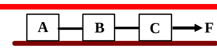


Let t_h be the time the beanbag hits the ground.

$$y(t_h) = 0 = h - \tfrac{1}{2}gt_h^2$$
$$x(t_h) = d = v_0 t_h$$

$$\tan\theta = \frac{|v_y(t_h)|}{|v_x(t_h)|} = \frac{gt_h}{v_0} = \frac{gt_h^2}{d} = \frac{2h}{d} = 4$$
$$\theta \approx 76^\circ$$

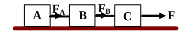
Exam 1 Fall 2010: Problem 8



- Three blocks (A,B,C), each having mass M_A = M, M_B= 2M, M_C = M are connected by strings on a horizontal frictionless surface as shown in the figure. Block C is pulled to the right by a horizontal force of magnitude F that causes the entire system to accelerate. What is the magnitude of the net horizontal force acting on block B due to the strings?

Answer: F/2
% Right: 41%

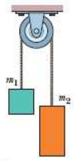
$$F = (M_A + M_B + M_C)a$$
$$F_B = (M_A + M_B)a$$
$$F_A = M_A a$$



$$F_{net}^B = F_B - F_A = M_B a = \frac{M_B}{M_A + M_B + M_C}F = \frac{2M}{M + 2M + M}F = \tfrac{1}{2}F$$

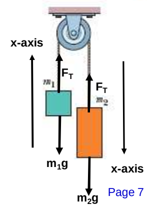
Exam 1 Fall 2010: Problem 9

- The figure shows two blocks with masses m_1 and m_2 connected by a cord (of negligible mass) that passes over a frictionless pulley (also of negligible mass). If $m_2 = 5m_1$ what is the magnitude of the acceleration of block 2 when released from rest?



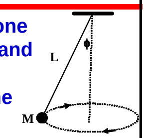
Answer: 2g/3
% Right: 85%

$$m_2 g - F_T = m_2 a_x$$
$$F_T - m_1 g = m_1 a_x$$
$$(m_2 - m_1)g = (m_1 + m_2)a_x$$
$$a_x = \frac{m_2 - m_1}{m_1 + m_2} g = \frac{5m_1 - m_1}{m_1 + 5m_1} g = \tfrac{2}{3} g$$



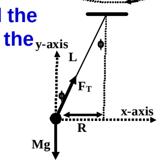
Exam 1 Spring 2012: Problem 20

- A conical pendulum is constructed from a stone of mass M connected to a cord with length L and negligible mass. The stone is undergoing uniform circular motion in the horizontal plane as shown in the figure. If the cord makes an angle θ = 30° with the vertical direction and the period of the circular motion is 4 s, what is the length L of the cord (in meters)?

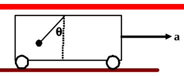


Answer: 4.59
% Right: 34%

$$T = \frac{2\pi R}{v} \qquad v^2 = \frac{4\pi^2 R^2}{T^2}$$
$$F_T\cos\phi - Mg = 0$$
$$F_T\sin\phi = Ma_x = M\frac{v^2}{R}$$
$$\tan\phi = \frac{v^2}{Rg} \qquad \sin\phi = \frac{R}{L}$$
$$\tan\phi = \frac{4\pi^2 R}{gT^2} \qquad R = \frac{gT^2\tan\phi}{4\pi^2} \qquad L = \frac{R}{\sin\phi}$$
$$L = \frac{gT^2}{4\pi^2\cos\phi} = \frac{(9.8m/s^2)(4s)^2}{4\pi^2\cos(30^\circ)} \approx 4.59m$$



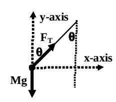
Exam 1 Spring 2012: Problem 37



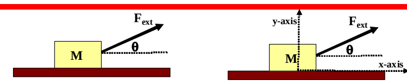
- Consider a mass M = 6 kg suspended by a very light string from the ceiling of a railway car near the surface of the Earth. The car has a constant acceleration as shown in the figure, causing the mass to hang at an angle θ with the vertical. If the acceleration of the railway car is a = 6 m/s², what is the tension in the string (in N)?

Answer: 68.9
% Right: 63%

$$Mg - F_T\cos\theta = 0 \qquad F_T\cos\theta = Mg$$
$$F_T\sin\theta = Ma_x$$
$$F_T^2 = M^2(g^2 + a_x^2)$$
$$F_T = M\sqrt{g^2 + a_x^2} = (6kg)\sqrt{(9.8m/s^2)^2 + (6m/s^2)^2} \approx 68.9N$$



Exam 1 Fall 2010: Problem 11



- Near the surface of the Earth, a block of mass M = 2 kg slides along the floor while an external force Fext is applied at an upward angle θ = 26°. If the coefficient of kinetic friction between the block and the floor is 0.488, and the magnitude of the acceleration of the block is 1.89 m/s², what is the magnitude of the external force?

Answer: 12 N
% Right: 59%

$$F_{ext}\cos\theta - f_k = Ma_x$$
$$F_{ext}\sin\theta + F_N - Mg = 0$$
$$f_k = \mu_k F_N$$
$$F_{ext} = \frac{M(a_x + \mu_k g)}{\cos\theta + \mu_k\sin\theta}$$
$$= \frac{(2kg)(1.89m/s^2 + (0.488)9.8m/s^2)}{\cos(26^\circ) + (0.488)\sin(26^\circ)} \approx 12.0N$$

Exam 2 Spring 2011: Problem 2

- A race car accelerates uniformly from a speed of 40 m/s to a speed of 58 m/s in 6 seconds while traveling around a circular track of radius 625 m. When the car reaches a speed of 50 m/s what is the magnitude of its total acceleration (in m/s²)?

Answer: 5
% Right: 49%

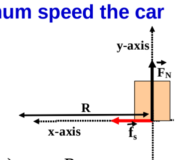
$$a_t = \frac{v_2 - v_1}{t_2 - t_1} = \frac{(58m/s) - (40m/s)}{6s} = 3m/s$$
$$a_r = \frac{v^2}{R} = \frac{(50m/s)^2}{625m} = 4m/s$$
$$a_{tot} = \sqrt{a_t^2 + a_r^2} = 5m/s$$

Exam 2 Spring 2011: Problem 4

- Near the surface of the Earth, a car is traveling at a constant speed v around a flat circular race track with a radius of 50 m. If the coefficients of kinetic and static friction between the car's tires and the road are μ_k = 0.1, μ_s = 0.4, respectively, what is the maximum speed the car can travel without slipping?

Answer: 14 m/s
% Right: 74%

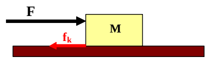
$$f_s = Ma_x = Ma_{radial} = M\frac{v^2}{R}$$
$$F_N - Mg = Ma_y = 0$$
$$fs \le \mu_s F_N$$
$$v_{max}^2 = \frac{R}{M}(f_s)_{max} = \frac{R}{M}(\mu_s F_N) = \frac{R}{M}(\mu_s Mg) = \mu_s gR$$
$$v_{max} = \sqrt{\mu_s gR} = \sqrt{(0.4)(9.8m/s^2)(50m)} = 14m/s$$



Exam 1 Fall 2010: Problem 20

- A horizontal force of magnitude 35 N pushes a block of mass 4 kg across a floor where the coefficient of kinetic friction is 0.6. What is the increase in the kinetic energy of the block when the block slides through a displacement of 5 m across the floor?

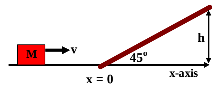
Answer: 57.4 J
% Right: 52%

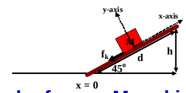


$$E_f = E_i + W$$
$$\Delta E = E_f - E_i = W$$
$$W = (F - f_k)d = (F - \mu_k Mg)d$$

$$\Delta KE = \Delta E = (F - \mu_k Mg)d = (35N - 23.52N)(5m) \approx 57.4J$$

Exam 1 Fall 2010: Problem 17





- Near the surface of the Earth a block of mass M and initial velocity 16.97 m/s is sliding to the right along the (negative) x-axis as shown. The surface is frictionless for x < 0. At x = 0 the block encounters a 45° incline ramp. If the block stops at a height h = 9.8 m, what is the kinetic coefficient of friction of the ramp?

Answer: 0.5
% Right: 41%

$$d = h/\sin\theta$$

$$E_f = E_i + W \qquad Mgh = \tfrac{1}{2}Mv^2 - f_k d$$
$$E_i = \tfrac{1}{2}Mv^2 \qquad F_N - Mg\cos\theta = 0$$
$$E_f = Mgh \qquad f_k = \mu_k F_N$$
$$W = -f_k d \qquad f_k = \mu_k Mg\cos\theta$$

$$\mu_k = \tan\theta\left(\frac{v^2}{2gh} - 1\right)$$
$$= \tan(45^\circ)\left(\frac{(16.97m/s)^2}{2(9.8m/s2)(9.8m)} - 1\right) \approx 0.5$$