

Physics 220 - Exam #2

ANSWER
KEYMarch 6th, 2001

This exam consist of 12 problems that are worth 5 points each for a total of 60 points. Please check that you have all of the questions.

Formulas and constants:

$$v = v_0 + at$$

$$x = v_0 t + 0.5 at^2 \quad y = v_0 t + 0.5 at^2$$

$$v^2 = v_0^2 + 2ax \quad v^2 = v_0^2 + 2ay$$

$$x = 0.5(v_0 + v)t \quad y = 0.5(v_0 + v)t$$

$$F = ma$$

$$F_{\text{grav}} = G \frac{m_1 m_2}{r^2}$$

$$f_{\text{max}} = \mu_s N \text{ (static friction)} \quad f_{\text{max}} = \mu_k N \text{ (sliding friction)}$$

$$a_c = v^2/r \quad KE = 0.5 m v^2 \quad PE_{\text{grav}} = mgh$$

$$W = F d \cos\theta \quad \text{power} = \text{work}/\Delta t$$

$$p = mv \quad \Delta p = \text{impulse} = F \Delta t$$

$$G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2$$

$$\text{Mass of the Earth} = 5.98 \times 10^{24} \text{ kg}$$

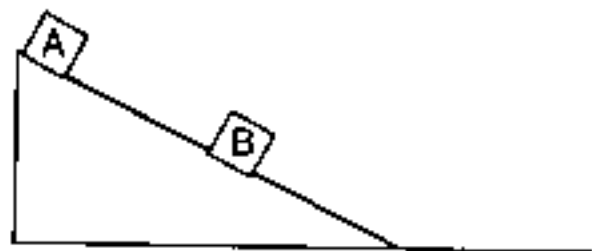
$$\text{Radius of the Earth} = 6.38 \times 10^6 \text{ m}$$

$$\text{Mass of the Mars} = 6.43 \times 10^{23} \text{ kg}$$

$$\text{Radius of the Mars} = 3.37 \times 10^6 \text{ m}$$

$$g = -9.8 \text{ m/s}^2$$

1. Two identical blocks in the figure are released simultaneously from rest on a frictionless inclined plane. They slide down the plane, then continue moving along a horizontal frictionless surface. A starts at the top, and B starts halfway down. Compare the kinetic energy (K), potential energy (U), and the total energy ($E = PE + KE$) at the instant B reaches the bottom of the incline.



$$PE_{0B} = \frac{1}{2}mgh$$

$$PE_{0A} = mgh$$

$$KE_{0B} = 0$$

$$KE_{0A} = 0$$

- (1) $KE_A > KE_B$, $PE_A > PE_B$, $E_A > E_B$
- (2) $KE_A > KE_B$, $PE_A < PE_B$, $E_A < E_B$
- (3) $KE_A > KE_B$, $PE_A > PE_B$, $E_A = E_B$
- (4) $KE_A < KE_B$, $PE_A = PE_B$, $E_A < E_B$
- (5) $KE_A < KE_B$, $PE_A > PE_B$, $E_A = E_B$
- (6) $KE_A = KE_B$, $PE_A = PE_B$, $E_A = E_B$
- (7) $KE_A > KE_B$, $PE_A < PE_B$, $E_A = E_B$
- (8) $KE_A > KE_B$, $PE_A = PE_B$, $E_A > E_B$
- (9) $KE_A < KE_B$, $PE_A > PE_B$, $E_A = E_B$
- (10) $KE_A = KE_B$, $PE_A > PE_B$, $E_A > E_B$

$$PE_A > PE_B$$

$$PE_{Bf} = 0$$

$$PE_{Af} = \frac{1}{2}mgh$$

$$KE_A = KE_B$$

$$KE_{Bf} = \frac{1}{2}mgh$$

$$KE_{Af} = \frac{1}{2}mgh$$

• both move $\frac{1}{2}h$

$$E_A > E_B$$

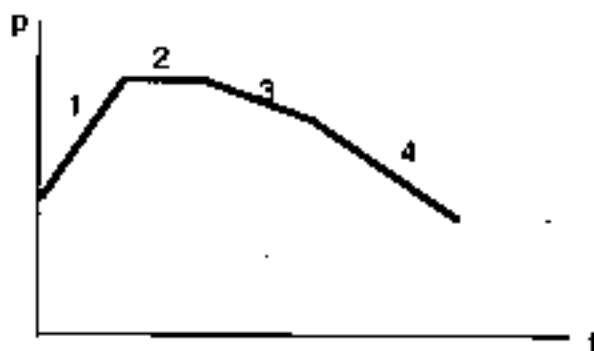
2. The law of conservation of momentum applies to a system of colliding objects only if:

- (1) The net external force is zero
- (2) There is no change in kinetic energy of the system
- (3) There is no internal energy release
- (4) The collisions are all elastic
- (5) The collisions are all inelastic
- (6) This law never applies to a system of objects.

$$op = F \Delta t$$

3. A particle moves along the x-axis. Its momentum is graphed below as a function of time. Rank the numbered regions according to the magnitude of the force acting on the particle, least to greatest.

- (1) 2,4,3,1
 (2) 3,4,1,2
 (3) 1,3,4,2
 (4) 4,1,2,3
 (5) 3,2,4,1
 (6) 1,4,3,2
 (7) 1,2,3,4
 (8) 2,3,4,1
 (9) 1,2,4,3
 (10) all are equal



$$\Delta p = F \Delta t$$

$$F = \frac{\Delta p}{\Delta t} \quad \text{slope}$$

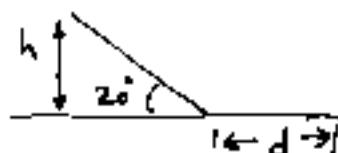
4. A skier starts from rest at the top of a smooth frictionless incline (inclined at 20.0°) of height 20.0 m . At the bottom of the incline, the skier encounters a horizontal rough surface where the coefficient of friction between the skis and the snow is 0.21 . How far does the skier travel on the horizontal surface before coming to rest?

- (1) 47.6 m
 (2) 9.72 m
 (3) 21.3 m
 (4) 0.231 m
 (5) 0 m
 (6) 1.98 m
 (7) 167 m
 (8) 95.2 m
 (9) 61.4 m
 (10) 33.3 m

$$F_d = W = \Delta KE$$

$$-\mu mg d = -\frac{1}{2} m v^2$$

$$d = \frac{v^2}{2\mu g} = \frac{h}{\mu}$$



$$mgh = \frac{1}{2} m v^2$$

$$v^2 = 2gh$$

$$KE = \frac{1}{2} m v_0^2 = mgh$$

$$v^2 = 2gh$$

Alternate

$$\Sigma F = -\mu mg = ma$$

$$-\mu = a/g$$

$$a = -\mu g$$

$$v_f^2 - v_i^2 = 2ad$$

$$d = \frac{-v_i^2}{2a} = \frac{-2gh}{-2\mu g} = \frac{h}{\mu}$$

5. Calculate the final velocity (in m/s) of a 110 kg football player initially running at 8.00 m/s who collides head on with a padded goalpost and experiences a backward force of 1.76×10^4 N for 5.50×10^{-2} seconds.

(1) 0.800 m/s

(2) 8.00 m/s

(3) 0.42 m/s

(4) 8.8 m/s

(5) -8.8 m/s

(6) -0.42 m/s

(7) -8.00 m/s

(8) -0.800 m/s

(9) not enough information

$$\Delta p = F \Delta t$$

$$m v_f - m v_i = F \Delta t$$

$$v_f = \frac{F \Delta t}{m} + v_i = -0.800 \text{ m/s}$$

$$F = -1.76 \times 10^4 \text{ N}$$

$$\Delta t = 5.5 \times 10^{-2} \text{ s}$$

$$m = 110$$

6. A 2 kg block of granite was given an initial velocity of 4.0 m/s but because of friction (between the granite and the floor) came to rest in 2.0 m. What is the magnitude of the frictional force (in Newtons) between the granite and the floor?

(1) 0.5

(2) 1.0

(3) 2.0

(4) 4.0

(5) 5.0

(6) 8.0

(7) 9.8

(8) 10.0

(9) 12.0

(10) 16.0

$$F \cdot d = \Delta KE$$

$$F = \frac{\frac{1}{2} m (v_f^2 - v_i^2)}{d} = \frac{-m v_i^2}{2d}$$

Alternate

$$v_i^2 = 2ax$$

$$a = \frac{v_i^2}{2x} = \frac{16}{2 \cdot 2} = 4 \text{ m/s}^2$$

$\leftarrow F \leftarrow$

$$\Sigma F = +\mu mg = m a$$

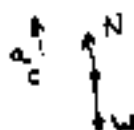
$$\mu = +a/g = 0.408$$

$$+\mu mg = F$$

7. A 200 lb student on a rotating Ferris wheel has an apparent weight of 125 lbs at the highest point. What is the student's apparent weight at the lowest point?

- (1) 25 lb
 (2) 75 lb
 (3) 125 lb
 (4) 150 lb
 (5) 175 lb
 (6) 200 lb
 (7) 50 lb
 (8) 225 lb
 (9) 275 lb
 (10) 325 lb

FBD Lowest point

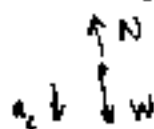


$$\Sigma F_y = N - W = F_c \quad \leftarrow \text{centripetal}$$

$$N - 200 = 75$$

$$N = 275$$

FBD Highest point

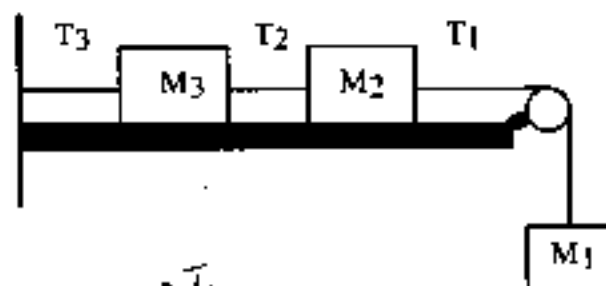


$$N - W = -F_c$$

$$F_c = 75 \text{ lbs}$$

8. Consider the arrangement shown in which two air track gliders are connected by strings to the end of the track on the left and to a hanging mass via a pulley on the right. No friction is present in the system. As configured, the system remains at rest. Compare the values of T_1 , T_2 and T_3 to the weight of the hanging block, W_1 , and to each other.

- (1) $T_3 > T_2 = T_1 = W_1$
 (2) $T_3 < T_2 = T_1 = W_1$
 (3) $T_3 > T_2 > T_1 > W_1$
 (4) $T_3 = T_2 = T_1 = W_1$
 (5) $T_3 < T_2 < T_1 < W_1$
 (6) $T_3 = T_2 = T_1 > W_1$
 (7) $T_3 = T_2 = T_1 < W_1$
 (8) $T_3 < T_2 < T_1 = W_1$
 (9) $T_3 > T_2 > T_1 = W_1$
 (10) none of the above



FBD 1

$$T_1 = W_1$$

FBD 2

$$T_2 = T_1$$

FBD 3

$$T_3 = T_2 = T_1 = W_1$$

9. A 50.0 kg boy runs at a speed of 10.0 m/s and jumps into a cart that is initially at rest. If the speed of the cart with the boy on it is 2.50 m/s, what is the mass of the cart?

- (1) 150 kg
 (2) 260 kg
 (3) 200 kg
 (4) 50 kg
 (5) 60 kg
 (6) 300 kg
 (7) 100 kg
 (8) 210 kg
 (9) 175 kg
 (10) Not enough information

$$P_i = P_f$$

$$m_B v_{0B} + m_C v_{0C} = (m_C + m_B) v_f$$

$$\frac{m_B v_{0B}}{v_f} - m_B = m_C$$

$$\frac{50 \times 10}{2.5} - 50 = m_C$$

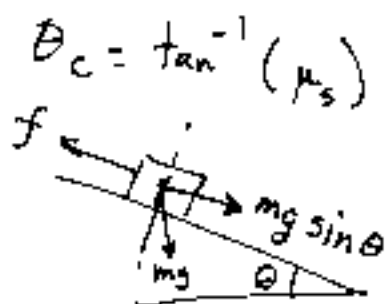
$$150 = m_C$$

10. A rock mass of 2.000×10^7 kg rests on an incline. The coefficient of static friction between the rock mass and the incline is 0.433. For what angle (in degrees) of the inclination (of the incline) will the rock mass just begin to slip?

- (1) 23.4
 (2) 21.2
 (3) 32.2
 (4) 35.4
 (5) 20.0
 (6) 25.6
 (7) 18.9
 (8) 39.1
 (9) 50.9
 (10) the rock mass will never slip.

$$\sum F_y = 0$$

$$N = mg \cos \theta$$



$$f = \mu N = \mu mg \cos \theta$$

$$\sum F_x = 0 \quad (\text{ verge of slipping })$$

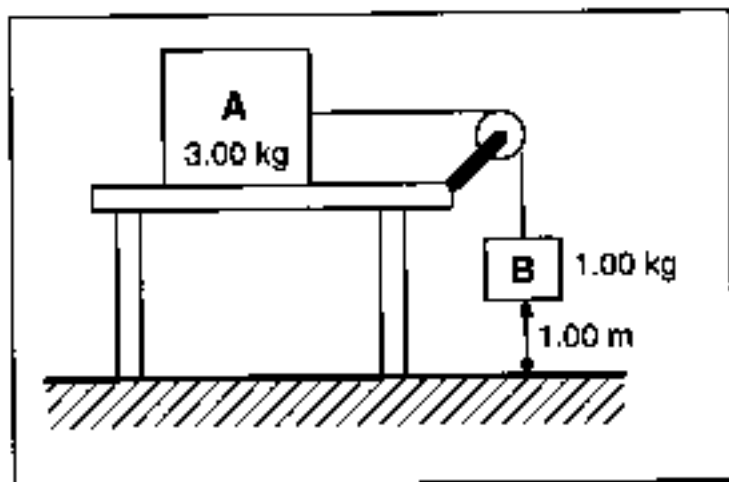
$$-\mu mg \cos \theta + mg \sin \theta = 0$$

$$\mu = \tan \theta$$

$$\theta = \tan^{-1}(\mu_s)$$

11. Two boxes are connected to each other as shown. The system is released from rest and the 1.00 kg box falls through a distance of 1.00 meter. The surface of the table is frictionless. What is the kinetic energy of box B just before it reaches the floor?

- (1) 9.80 J
 (2) 39.2 J
 (3) 0 J
 (4) 29.4 J
 (5) 2.45 J
 (6) 3.27 J
 (7) 7.35 J
 (8) 14.7 J
 (9) 6.53 J
 (10) 4.90 J



$$K_0 = 0$$

$$m_A = 3m_B$$

$$E_i = E_f$$

$$m_B gh = \frac{1}{2} m_B v_B^2 + \frac{1}{2} m_A v_A^2$$

$$m_B gh = 4 \left(\frac{1}{2} m_B v_B^2 \right)$$

$$\frac{1}{4} m_B gh = KE_B$$

$$m_B gh + m_A gh \cdot \frac{1}{2}$$

$$= \frac{1}{2} m_A v^2 +$$

$$\frac{1}{2} m_B v^2$$

$$+ m_A gh \cdot \frac{1}{2}$$

$$v^2 = \frac{2m_B}{m_A + m_B} gh$$

12. An engineer is asked to design a playground slide such that the speed of a child reaches at the bottom does not exceed 6.00 m/s. Determine the maximum height that the slide can be.

$$v^2 = \frac{2}{4} gh$$

$$E_i = E_f$$

$$mgh = \frac{1}{2} mv^2$$

$$h = \frac{v^2}{2g}$$

$$KE_B = \frac{1}{2} mv^2$$

$$= \frac{1}{2} \cdot \frac{2}{4} \cdot 1 \cdot gh$$

$$= \frac{1}{4} \cdot 1.98 \cdot 1$$

$$= \frac{1}{4} \cdot 9.8$$

$$= 2.45 \text{ J}$$

- (1) 1.8 m
 (2) 14 m
 (3) 2.9 m
 (4) 3.2 m
 (5) 1.3 m
 (6) 0.8 m
 (7) 5.0 m
 (8) 1.0 m
 (9) 4.5 m
 (10) not enough information