

Physics 220 – Exam #2

March 4th, 2002

This exam consist of 10 problems that are worth 10 points each for a total of 100 points. Please check that you have all of the questions.

Formulas and constants:

$$v = v_0 + at$$

$$x = v_0 t + 0.5 at^2$$

$$v^2 = v_0^2 + 2ax$$

$$x = 0.5(v_0 + v)t$$

$$y = v_0 t + 0.5 at^2$$

$$v^2 = v_0^2 + 2ay$$

$$y = 0.5(v_0 + v)t$$

$$\mathbf{F} = m\mathbf{a}$$

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

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

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

$$\mathbf{a}_c = v^2/r$$

$$\text{KE} = 0.5 m v^2$$

$$\text{PE}_{\text{gravity}} = mgh$$

$$W = F d \cos\theta$$

$$\text{power} = \text{work}/\Delta t$$

$$\mathbf{p} = m\mathbf{v}$$

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

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

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

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

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

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

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

1. A 500 kg sack of coal is dropped on a 2000 kg railroad flatcar that was initially moving at 3.0 m/s. After the sack rests on the flatcar, find the speed of the flatcar in m/s:

(1) 0.6

(2) 1.2

(3) 0

(4) 4.2

(5) 0.8

(6) 5.7

(7) 3.6

(8) 1.8

(9) 0.16

(10) 2.4

$$m_1 = 500 \text{ kg}$$

$$v_{10} = 0$$

$$m_2 = 2000 \text{ kg}$$

$$v_{20} = 3.0 \text{ m/s}$$

$$\vec{p}_i = \vec{p}_f$$

$$m_1 v_{10} + m_2 v_{20} = (m_1 + m_2) v_f$$

$$v_f = \frac{m_1 v_{10} + m_2 v_{20}}{m_1 + m_2}$$

$$v_f = \frac{(2000)(3)}{2500} = 2.4 \text{ m/s}$$

2. Two identical blocks in the figure are released simultaneously from rest on a frictionless inclined plane. A starts at the top, and B starts halfway down. If the time it takes to reach the bottom of the ramp is t_A for block A and t_B for block B. Then t_A/t_B is:

(1) 1

(2) $\sqrt{2}$

(3) 2

(4) 0.33

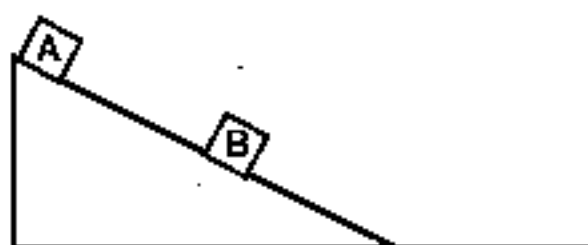
(5) 0.25

(6) 4

(7) 0.5

(8) 8

(9) 6

(10) $\sqrt{2}/2$ 

For Block A

$$mgh_A = \frac{1}{2} m v_A^2$$

$$v_A = \sqrt{2gh_A}$$

$$v_A = \frac{L}{t_A} \quad t_A = \frac{L}{v_A} = \frac{L}{\sqrt{2gh_A}}$$

For Block B $h_B = \frac{1}{2} h_A$

$$mg \frac{1}{2} h_A = \frac{1}{2} m v_B^2$$

$$v_B = \sqrt{gh_A}$$

$$t_B = \frac{\frac{1}{2} L}{v_B} = \frac{L}{2\sqrt{gh_A}}$$

$$\frac{t_A}{t_B} = \frac{L}{\sqrt{2gh_A}} \cdot \frac{2\sqrt{gh_A}}{L} = \sqrt{2}$$

3. An 800.0 N passenger in a car presses against the car door with a 200.0 N force when the car makes a left turn at 13.0 m/s (assume circle motion). The faulty door will pop open under a force of 800.0 N. Find the least speed (in m/s) for which the man is thrown out of the car for the same radius turn.

- (1) 10
 (2) 15
 (3) 19
 (4) 22
 (5) 30
 (6) 0
 (7) 26
 (8) 7
 (9) 54
 (10) 13

①

$$F = \frac{mv^2}{r}$$

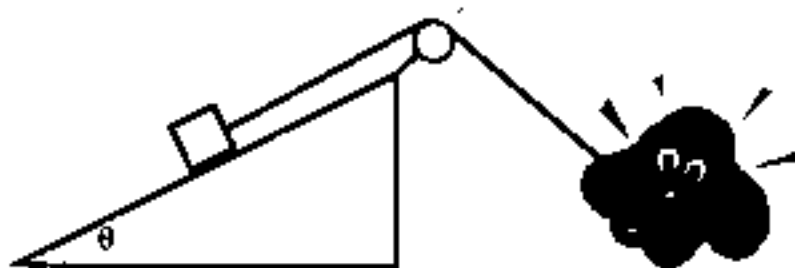
$$r = \frac{mv^2}{F} = \left(\frac{800}{9.8}\right) \frac{13^2}{200} \approx 69 \text{ m}$$

②

$$v = \sqrt{\frac{Fr}{m}} = \sqrt{\frac{800 \times 69}{(800/9.8)}} = 26$$

4. A dog has pulled a 100 N crate up a frictionless $\theta = 30^\circ$ slope to a vertical height of 5 m. Find the work done by the dog (in Joules).

- (1) -1000
 (2) -500
 (3) -350
 (4) -225
 (5) -150
 (6) 150
 (7) 225
 (8) 350
 (9) 500
 (10) 1000



$$W = mgh = 100 \text{ N} \times 5 \text{ m} = 500 \text{ J}$$

Positive because work done by dog moves the block.

5. The system shown has two blocks that have the same weight, W . The blocks remain at rest. Find the force of friction on the block on the ramp in Newtons. The pulley is frictionless. $W = 20 \text{ N}$. $a = 3 \text{ m}$
 $b = 4 \text{ m}$

(1) 4

(2) 24

(3) 20

(4) 12

(5) 8

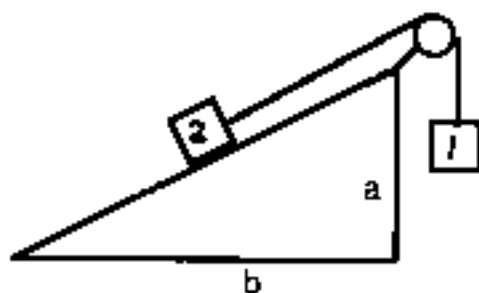
(6) 16

(7) 2

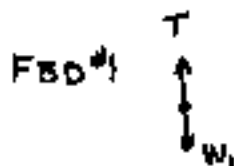
(8) 14

(9) 18

(10) 10

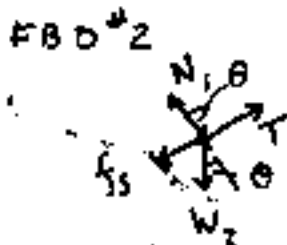


$$\theta = 36.87^\circ$$



$$T = W_1 \quad \leftarrow \quad \sum F_y = 0$$

$$W_1 = W_2$$



$$\sum F_x = 0$$

$$T - f_s - W_2 \sin \theta = 0$$

$$-f_s = W_2 \sin \theta - W_2$$

$$-f_s = W_2 (\sin \theta - 1) = -8 \text{ N}$$

6. A 2100.0 kg demolition ball swings at the end of a 15.0 m cable on the arc of a vertical circle. At the lowest point of the swing, the ball is moving at a speed of 7.60 m/s. Find the tension (in kiloNewtons) in the cable.

(1) 20.6

(2) 21.6

(3) 2.1

(4) 12.5

(5) 24.5

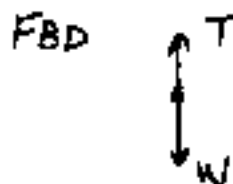
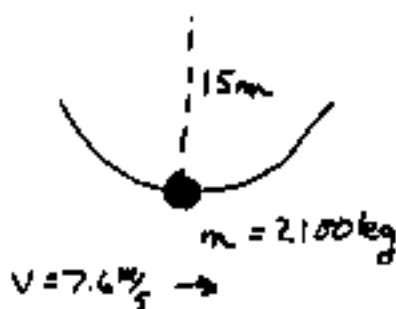
(6) 17.7

(7) 2.5

(8) 28.6

(9) 31.3

(10) 25.8

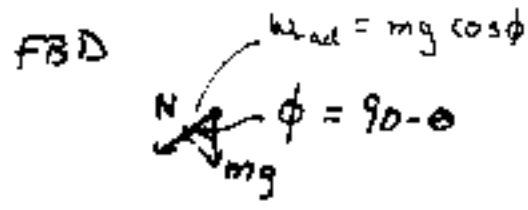
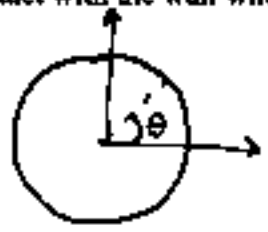


$$\sum F_y = T - W = ma_c = \frac{mv^2}{r}$$

$$T = 28.6 \text{ kN}$$

7. In an automatic clothes drier, a hollow cylinder moves the clothes on a vertical circle (radius = 0.32 m). The appliance is designed so that the clothes tumble gently as they dry. This means that when a piece of clothing reaches an angle θ above the horizontal, it loses contact with the wall of the cylinder and falls onto the clothes below. Find the number of revolutions per second that the cylinder should make in order that the clothes lose contact with the wall when $\theta = 70^\circ$.

- (1) 1.7
- (2) 0.85
- (3) 1.0
- (4) 2.1
- (5) 0.75
- (6) 0.52
- (7) 1.3
- (8) 0.12
- (9) 0.41
- (10) 3.1



$$\sum F_{\text{radial}} = -F_N - mg \cos \phi = -\frac{mv^2}{r}$$

$$mg \sin \theta = \frac{mv^2}{r}$$

$$v = \sqrt{rg \sin \theta}$$

$$\left[\begin{aligned} \cos \phi &= \cos(90 - \theta) \\ &= \sin \theta \end{aligned} \right]$$

$$\frac{1}{T} = \frac{v}{2\pi r} = \frac{\sqrt{rg \sin \theta}}{2\pi r} = 0.85 \text{ rev/s}$$

8. A basketball ($m = 0.60 \text{ kg}$) is dropped from rest. Just before striking the floor, the magnitude of the basketball's momentum is 3.1 kg m/s . Find the height (in meters) from which the basketball was dropped.

- (1) 0.26
- (2) 0.19
- (3) 0.45
- (4) 0.82
- (5) 0.33
- (6) 0.75
- (7) 1.4
- (8) 2.7
- (9) 3.2
- (10) 0.01

(1) $v_y^2 = v_i^2 + 2a_y y$

$v_{iy} = 0$

$v_y^2 = 2a_y y$
 $y = \frac{v_y^2}{2a_y}$

(2) $\vec{p} = m\vec{v}$
 $\vec{v} = \frac{\vec{p}}{m}$

$$y = \frac{p^2}{m^2} \frac{1}{2a} = \frac{(3.1)^2}{(0.60)^2} \frac{1}{2 \times 9.8} = 1.36 \text{ m} = 1.4 \text{ m}$$

9. A projectile of mass 0.750 kg is shot straight up with an initial speed of 18.0 m/s. If the projectile rises to a maximum height of only 11.8 m, find the magnitude of the average force (in Newtons) due to air resistance.

$$m = 0.750 \text{ kg}$$

$$v_0 = 18.0 \text{ m/s}$$

$$h_{\text{max}} = 11.8 \text{ m}$$

(1) 1.03

(2) 2.95

(3) 7.35

(4) 4.90

(5) 8.12

(6) 5.93

(7) 0.397

(8) 0.623

(9) 10.8

(10) 17.6

$$W_{nc} = \Delta KE + \Delta PE = Fd \cos \theta$$

$$\frac{1}{2} m (v_f^2 - v_0^2) + mg(h_f - h_0) = Fd \cos 180 = -Fd$$

$$F = \frac{\frac{1}{2} m v_0^2 - mgh_f}{d} = 2.95 \text{ N}$$

10. Masses m_1 and m_2 are connected by a massless string of fixed length that goes over a massless frictionless pulley. As mass m_2 falls due to gravity, m_2 pulls mass m_1 across the table. The coefficient of kinetic friction between m_1 and the table is μ_k . Find the tension (in Newtons) in the string. Assume $m_1 = m_2 = 2.0 \text{ kg}$, and $\mu_k = 0.16$

(1) 4.12

(2) 5.68

(3) 9.8

(4) 11.4

(5) 7.25

(6) 0

(7) 0.381

(8) 12.6

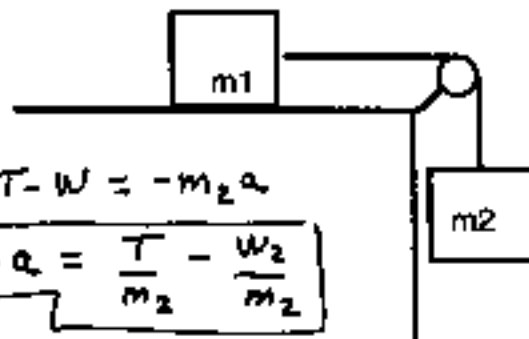
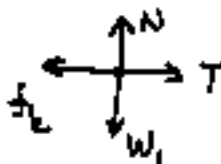
(9) 0.16

(10) 2.37

FBD for m_2 

$$\sum F_y = T - W = -m_2 a$$

$$\text{(A)} \quad -a = \frac{T}{m_2} - \frac{W_2}{m_2}$$

FBD for m_1 

$$\sum F_y = 0 = N - W_1 = 0 \Rightarrow N = W_1 = m_1 g$$

$$\sum F_x = T - f_k = m_1 a$$

$$\text{(B)} \quad T = m_1 a + f_k$$

USE (A) & (B)

$$T = \frac{m_2 m_1 g}{m_2 + m_1} (1 + \mu_k) = 11.4 \text{ N}$$