

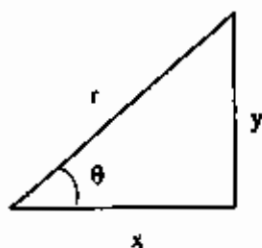
Physics 220 – Final Exam

May 7

2004

This exam consists of 15 problems on 17 pages. Please check that you have them all.

All of the formulas that you will need are given below. You may also use a calculator.



$$\sin \theta = y/r \quad \cos \theta = x/r \quad \tan \theta = y/x$$

$$\text{average speed} = \frac{\text{distance traveled}}{\text{time}} \quad g = 9.8 \text{ m/s}^2$$

$$\text{average velocity} = \vec{v} = \frac{\text{displacement}}{\text{time}}$$

instantaneous velocity = slope of position versus time

instantaneous acceleration = slope of velocity versus time

For constant acceleration:

$$x = x_0 + v_0 t + \frac{1}{2} a t^2 \quad v = v_0 + a t \quad v^2 = v_0^2 + 2a(x - x_0)$$

$$\vec{F} = m\vec{a} \quad F_{\text{friction}}^{\text{max}} = \mu_s N \text{ (static friction)} \quad F_{\text{friction}} = \mu_k N \text{ (sliding friction)}$$

$$F_{\text{gravity}} = \frac{G m_1 m_2}{r^2} \quad G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$$

$$a_c = v^2/r \quad KE = \frac{1}{2} m v^2 \quad W = F d \cos \theta \quad PE_{\text{gravity}} = mgh$$

$$\text{power} = \text{work}/\Delta t \quad \vec{p} = m\vec{v} \quad \Delta p = \text{impulse} = F \Delta t$$

$$F_{\text{spring}} = -kx \quad PE_{\text{spring}} = \frac{1}{2} k x^2 \quad x = A \cos(\omega t) \quad v = -A\omega \sin(\omega t)$$

$$\omega = \sqrt{k/m} \quad \omega = \sqrt{g/L} \quad \omega = 2\pi f \quad f = 1/T \quad a = -A\omega^2 \cos \omega t$$

For constant angular acceleration:

$$\theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2 \quad \omega = \omega_0 + \alpha t \quad \omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$

$$KE = I\omega^2/2 \quad L = I\omega \quad \tau = I\alpha \quad \theta = s/r \quad \omega = v/r \quad \alpha = a/r \quad \omega = \theta/t$$

$$\tau = F_{\perp} \ell \quad I = \sum_i m_i R_i^2$$

$$\text{Pressure} = \text{Force/area} \quad P_{\text{atm}} = 1.0 \times 10^5 \text{ Pa.} \quad A_1 v_1 = A_2 v_2$$

$$P_1 + \rho g h_1 + \rho v_1^2/2 = P_2 + \rho g h_2 + \rho v_2^2/2$$

Archimedes principle: buoyant force = weight of fluid displaced

$$v = f\lambda \quad T = 1/f \quad y = A \sin(2\pi ft - 2\pi x/\lambda)$$

$$I = \frac{\text{Power}}{\text{area}} = \frac{P}{4\pi R^2} \quad , \quad I \propto |A|^2 \quad , \quad \beta = 10 \log_{10} \frac{I}{I_0} \quad , \quad I_0 = 10^{-12} \text{ W/m}^2$$

$$f_{\text{obs}} = (1 \pm v_0/v) f_{\text{source}} \quad , \quad f_{\text{obs}} = \frac{f_{\text{source}}}{(1 \mp v_0/v)}$$

$$\Delta L/L = \alpha \Delta T$$

$$PV = nRT \quad (T \text{ in Kelvin}) = 273 + (T \text{ in Celsius}) \quad U_i = 3nRT/2$$

$$\text{Avogadro's number} = 6.02 \times 10^{23} \text{ particles per mole} \quad R = 8.31 \text{ J/mole} - \text{K}$$

$$KE_{\text{ave}} = \frac{1}{2} m (V_{\text{rms}})^2 = 3kT/2 \quad k = 1.4 \times 10^{-23} \text{ J/K} \quad \Delta U = Q - W$$

$$W = \text{area under } P - V \text{ curve} \quad T = 1/f \quad y = A \sin(2\pi ft - 2\pi x/\lambda)$$

$$y = A \cos(2\pi ft - 2\pi x/\lambda)$$

$$Q = mL \quad Q = mc\Delta T \quad W = nRT \ln \left(\frac{V_f}{V_i} \right)$$

$$W = P\Delta V \quad 1 \text{ cal} = 4.186 \text{ J} \quad 1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$$

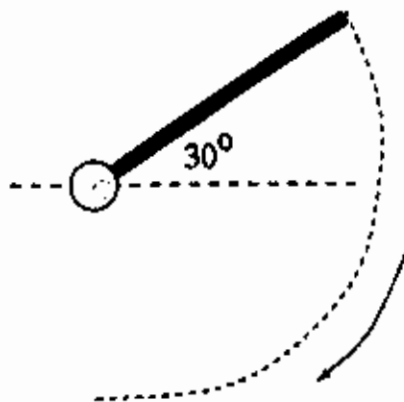
1. A rock of mass 1 kg is thrown horizontally with a speed 10 m/s on top of a building which is 50 m above the ground. Ignoring air resistance, find the time it takes the rock to reach the ground.
- a) 2.3 s
 - b) 3.2 s
 - c) 10 s
 - d) 0.1 s
 - e) 5.0 s

2. You like to ride roller coasters. Your favorite one has a circular shape with radius 20 m. When you are at the top, you feel as if your weight is only a third of your true weight. What is the speed of the roller coaster?



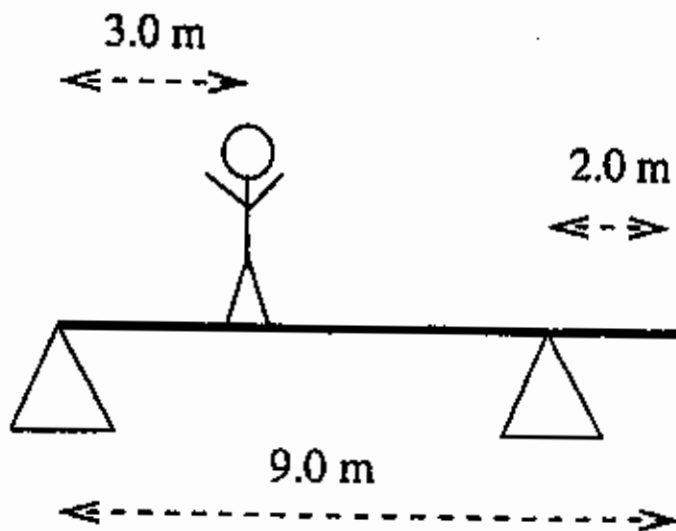
- a) 14 m/s
- b) 130 m/s
- c) 1.5 m/s
- d) 5.1 m/s
- e) 11 m/s

3. A rod of length 2.5 m is hinged at one end. It starts from rest and swings to the bottom of its arc. Find the speed of the **END** of the rod when it reaches the bottom. The moment of inertia of a rod that pivots about one end is $I = ML^2/3$.



- a) 8.6 m/s
- b) 7.0 m/s
- c) 11 m/s
- d) 14 m/s
- e) 4.5 m/s

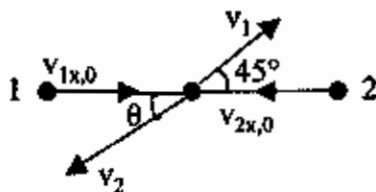
4. A plank of length 9.0 m and mass 45 kg sits at rest on two supports as shown below. The mass of the plank is distributed uniformly. A child of mass 35 kg also sits on the plank a distance 3.0 m from the left end. Find the force of the *left* support on the plank.



- a) 200 N
b) 160 N
c) 410 N
d) 2500 N
e) 350 N
5. A man (mass = m) stands at the edge of a rotating turntable, which has a radius R and a moment of inertia I . The initial angular velocity is $\omega = 8$ rad/s. The man walks radially inward till he reaches the center. What is the final angular velocity (in rad/s) of the system? Assume that the man's mass satisfies the relation $mR^2 = 3I$, and that, when he reaches the center, his moment of inertia is $I/10$.
- a) 32
b) 16
c) 1.5
d) 29
e) 10

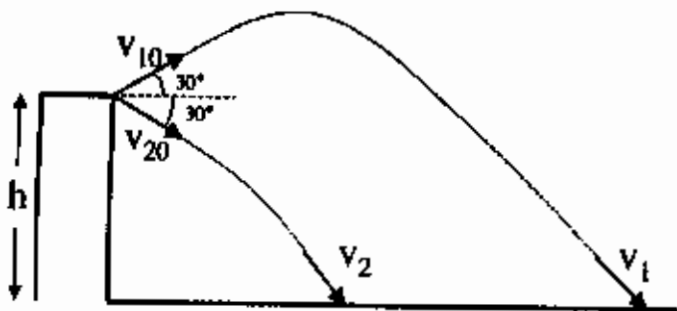
6. Two particles, of equal mass $m_1 = m_2 = 1$ kg, collide with equal and opposite velocities along the x-direction, $v_{1x,0} = -v_{2x,0} = 3$ m/s. After the collision, particle #1 moves with $v_1 = 2$ m/s along the 45° (Northeast) direction. The speed (v_2) and angle (θ) of particle #2 are:

- a) $v_2 = 3$ m/s, $\theta = 45^\circ$
 b) $v_2 = 2$ m/s, $\theta = 45^\circ$
 c) $v_2 = 2.5$ m/s, $\theta = 45^\circ$
 d) $v_2 = 2$ m/s, $\theta = 30^\circ$
 e) $v_2 = 3$ m/s, $\theta = 30^\circ$



A student of physics performed the following experiment. From a window at height h ($h = 10$ m), she threw two rocks with the same speed ($v_{10} = v_{20} = 10$ m/s). One went upward at 30° and the other went downward at 30° , as shown in the diagram. She then measured the speeds v_1 and v_2 of the two rocks as they hit the ground. Predict the results of her measurements.

- a) $v_1 = 34$ m/s, $v_2 = 17$ m/s
 b) $v_1 = 20$ m/s, $v_2 = 30$ m/s
 c) $v_1 = 21$ m/s, $v_2 = 25$ m/s
 d) $v_1 = 17$ m/s, $v_2 = 17$ m/s
 e) $v_1 = 17$ m/s, $v_2 = 34$ m/s



8. An apple floats in a barrel of water. If you lift the apple 1.0 cm above its floating level and release it at time $t = 0$, it bobs down and then up with a period $T = 0.650$ s. Assuming the motion is simple harmonic motion, find the speed (in cm/s) of the apple for the time equal to $T/4$.

- a) 0.25
- b) 4.0
- c) 9.7
- d) 14.5
- e) 1.8



9. One of the pipes in your apartment springs a small leak, and the water sprays out at a speed of 16 m/s. Assuming that the water in the pipe is (approximately) static, what is the water pressure inside the pipe? ($P_{\text{atm}} = 1.0 \times 10^5$ Pa, $\rho_{\text{water}} = 1000$ kg/m³)
- a) 2.3×10^5 Pa
 - b) 1.3×10^5 Pa
 - c) 1.0×10^5 Pa
 - d) 2.8×10^4 Pa
 - e) 5.3×10^5 Pa

10. You are asked to design a pendulum whose period of oscillation (T) is 4 seconds. The pendulum has a heavy mass (2 kg) attached to a long rod with negligible mass. What should be the length of the rod?
- a) 1.5 m
 - b) 2.0 m
 - c) 1.0 m
 - d) 3.0 m
 - e) 4.0 m
11. A loudspeaker, whose power is spread out isotropically, produces a sound intensity level of 60 dB at a distance of $R = 10$ m. At a distant of $R = 100$ m, what is the sound intensity level produced by the same power?
- a) 50 dB
 - b) 80 dB
 - c) 40 dB
 - d) 70 dB
 - e) 65 dB

12. The Purdue WBAA FM station broadcasts at the frequency 101×10^6 Hz. If the (electromagnetic) wave travels at the speed of 3.0×10^8 m/s, find the wavelength.
- a) 3.0 m
 - b) 2.0 m
 - c) 1.8 m
 - d) 2.5 m
 - e) 4.0 m
13. Find the average speed (v_{rms}) of an oxygen molecule (O_2) in the atmosphere. Assume that the atmosphere can be treated as an ideal gas at 20° C. The mass of the oxygen molecule is $32 \text{ u} = 5.3 \times 10^{-26}$ kg.
- a) 480 m/s
 - b) 14 m/s
 - c) 190 m/s
 - d) 31 m/s
 - e) 330 m/s

14. A motor boat with a siren travels towards a woman on a stationary fishing boat. The frequency measured when the boat is approaching is 700 Hz and when receding is 620 Hz, and the velocity of sound in air on this day is 330 m/s. What is the speed of motorboat?
- a) 10 m/s
 - b) 20 m/s
 - c) 30 m/s
 - d) 40 m/s
 - e) 50 m/s

15. 2.0 kg of ice is initially at -10°C . How much heat must be added to the system so that its final temperature is $+20^{\circ}\text{C}$? The latent heat of fusion is 33,000 J/kg, the specific heat of ice is 2,000 J/(K·kg) and the specific heat of water is 4200 J/(K·kg). The melting point is 0° .
- a) $2.7 \times 10^5\text{ J}$
 - b) $1.4 \times 10^5\text{ J}$
 - c) $4.2 \times 10^4\text{ J}$
 - d) $8.3 \times 10^4\text{ J}$
 - e) $3.4 \times 10^5\text{ J}$

Key to Phys. 220 FINAL EXAM

1. B

2. E

3. C

4. E

5. D

6. B

7. D

8. C

9. A

10. E

11. C

12. A

13. A

14. B

15. A