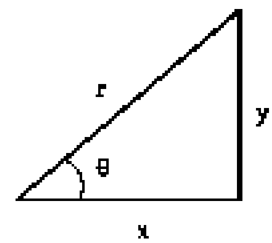
Key

Physics 220 – Exam #3

November 16 **2000**

This exam consists of 12 problems on 7 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.



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

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

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

$\vec{F} = m\vec{a}$ $F^{max}_{friction} = \mu_S N$ (static friction) $F_{friction} = \mu_K N$ (sliding friction)

$F_{gravity} = \frac{Gm_1m_2}{r^2}$ $G = 6.67 \times 10^{-11}$ Nm^2/kg^2

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

power = work/Δt $\vec{p} = m\vec{v}$ Δp = impulse = $F\,\Delta t$

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

$\omega = \sqrt{k/m}$ $\omega = \sqrt{g/L}$ $\omega = 2\pi f$ $f = 1/T$

For constant angular acceleration:
$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$ $\omega = \omega_0 + \alpha t$ $\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$

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

Pressure = Force/area $A_1v_1 = A_2v_2$ $P_1 + \rho g h_1 + \rho v_1^2/2 = P_2 + \rho g h_2 + \rho v_2^2/2$

Archimedes principle: buoyant force = weight of fluid displaced

1. You have just purchased an old-fashioned record player, which generates music from vinyl disks called records. If a record spins at 33 revolutions per minute (33 rpm), find the period of the motion.

   (a) 33 s
   (b) 0.35 s
   (c) 0.29 s
   (d) 0.030 s
   (e) 1.8 s

$$T = \frac{1\ min}{33\ rev} = \frac{60\ sec}{33} = 1{,}8\ s/rev$$

2. A compact disc player spins CDs at an angular speed of 15 radians/s. If it starts from rest and has an angular acceleration of 4.3 radians/s^2, how long does it take to reach its operating speed?

   (a) 3.5 s
   (b) 0.23 s
   (c) 7.0 s
   (d) 0.29 s
   (e) 0.067 s

$$\omega = \omega_0 + \alpha t$$
$$15 = 0 + 4{,}3 \cdot t$$
$$t = \frac{15}{4.3} = 3{,}5\ s$$

3. A particle attached to a spring with spring constant $k = 125\,\mathrm{N/m}$ is undergoing simple harmonic motion, and its position is given by the equation $x = 17\cos(14t)$. Find the mass of the particle.

(a) 8.9 kg
(b) 0.11 kg
(c) 14 kg
(d) 1.6 kg
(e) 0.64 kg

$\rightarrow$ D

$$x = A\cos \omega t$$

$$\omega = 14 = \sqrt{\frac{k}{m}}$$

$$\omega^2 = \frac{k}{m} \qquad m = \frac{k}{\omega^2} = \frac{125}{14^2} = 0.64\ \text{kg}$$

4. A golf ball is hit with an initial velocity of 50 m/s at an angle of 60° with respect to the horizontal. How long does it spend in the air?

(a) 10.2 s
(b) 8.8 s
(c) 5.1 s
(d) 23 s
(e) 4.4 s

$\rightarrow$ D

$$y = y_0 + v_{y_0} t - \tfrac{1}{2} g t^2$$

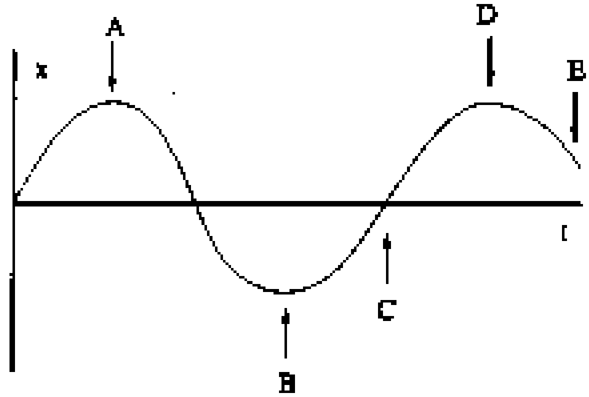
$$0 = 0 + v_0 \sin 60\, t - \tfrac{1}{2} g t^2$$

$$v_0 \sin 60 = \tfrac{1}{2} g t$$

$$t = \frac{2 v_0 \sin 60}{g} = \frac{2(50)\sin 60}{9.8}$$

$$= 8.85$$

5. The figure below shows the position as a function of time for an object undergoing simple harmonic motion. One complete period of the motion corresponds to which interval?



(a) The time between A and B

(b) The time between A and C

(c) The time between A and D

(d) The time between A and E

(e) The time between B and D

6. You like to swim at a nearby lake. On one side of the lake is a cliff and the top of the cliff is 6.5 m above the surface of the lake. If you jump horizontally off the cliff so as to have an angular speed of 2.2 revolutions/s, how many revolutions do you make before you hit the water?

(a) 1.3

(b) 64

(c) 2.5

(d) 5.8

(e) 0.45

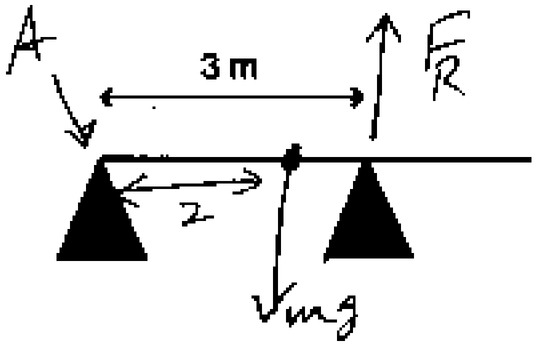
First find time in air

$\frac{1}{2} g t^2 = 6.5\,m$

$t = \sqrt{\frac{2(6.5)}{g}}$

\# of revolution $= \omega t = 2.2 \sqrt{\frac{2(6.5)}{9.8}} = \underline{2.5 \text{ rev}}$

7. A plank of length 4.0 m sits at rest on two supports as shown below. The mass of the plank is 50 kg and is distributed uniformly. Find the force of the right support on the planck.



(a) 120 N

(b) 370 N

(c) 160 N

(d) 330 N

(e) 490 N

Calculate torque with respect to point A

$$\tau_A = mg \cdot 2 - F_R \cdot 3 = 0$$

$$F_R = \frac{2mg}{3} = \frac{2(50)9.8}{3} = \underline{330N}$$

8. A box of valuable metal of volume 2.3 m^3 is sitting on the bottom of a lake. If the minimum force required to lift the box is 2.3×10^4 N, find the density of the box. ($\rho_{water} = 1000$ kg/m^3)

(a) 1000 kg/m^3

(b) 2000 kg/m^3

(c) 500 kg/m^3

(d) 3000 kg/m^3

(e) 8000 kg/m^3

F_{lift} = weight − buoyant force

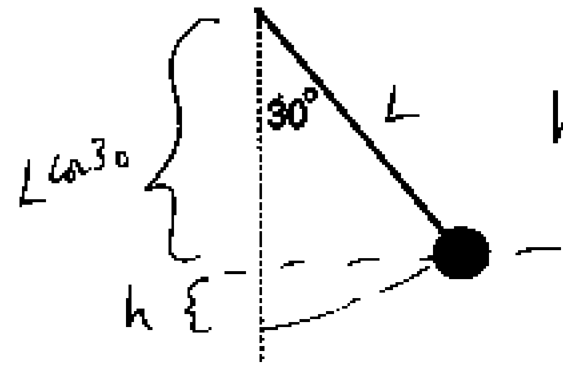
$$F = \rho_{metal} \cdot V \cdot g - \rho_{water} \cdot V \cdot g$$

$$\rho_{metal} = \frac{F}{Vg} + \rho_{water}$$

$$= \frac{2.3 \times 10^4}{2.3(9.8)} + 1000$$

$$= 1020 + 1000 = \underline{2000\ kg/m^3}$$

9. A rock of mass 12 kg is tied to a massless string of length 2.1 m. The rock is held at rest as shown so that the string is initially tight, and then released. Find the speed of the rock when it reaches the lowest point of its trajectory.



$h = L - L\cos 30$
$= L(1 - \cos 30)$

(a) 0.55 m/s
(b) 0.74 m/s
(c) 0.28 m/s
(d) 6.0 m/s
(e) 2.3 m/s

$\frac{1}{2} m v^2 = m g h$

$v = \sqrt{2gh} = \sqrt{2 \cdot 9.8 \cdot 2.1(1 - \cos 30)}$

$= 2.3$ m/s

10. Consider a swimming pool which is 7 m on a side and 10 m deep. Find the total force of the water on one of the side walls of the pool. ($\rho_{water} = 1000$ kg/m^3; $P_{atm} = 1.0 \times 10^5$ Pa)

(a) 7.0×10^6 N
(b) 3.4×10^5 N
(c) 2.1×10^7 N
(d) 3.1×10^7 N
(e) ~~[illegible]~~ $\times 10^6$ N

oops 10.4×10^6

P_{ave} = Pressure at a depth of 3.5 m.

$= P_0 + \rho g h =$ ~~P_0~~

$1.0 \times 10^5 + 1000 (9.8)(5.0) = 1.49 \times 10^5$

$F = P \cdot 7 \cdot 10 = 10.4 \times 10^6$

All students will get full credit for this problem.

Sorry.

11. The surface of the water in the water tower next to you house is 20 m above the level of the faucet in your kitchen. When you open the faucet, what is the speed of the water when it sprays out of the faucet? Assume that the opening of the faucet is much smaller than the size of the water tower. ($\rho_{water} = 1000$ kg/m^3; $\rho_{air} = 1.3$ kg/m^3; $P_{atm} = 1.0 \times 10^5$ Pa)

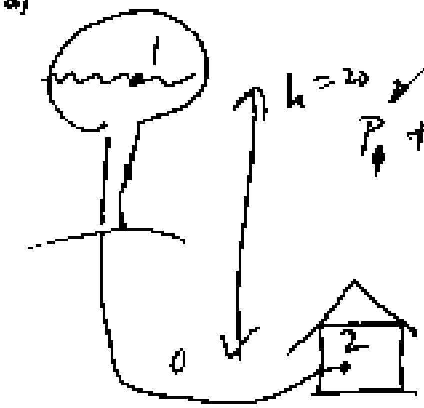
(a) 7.0 m/s

(b) 2.2 m/s

(c) 14 m/s

→ (d) 20 m/s

(e) 390 m/s



P_{atm} $\quad$ 0

$$P_1 + \rho g h_1 + \tfrac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \tfrac{1}{2}\rho v_2^2$$

≈ 0

$$\rho g h_1 = \tfrac{1}{2}\rho v_2^2$$

$$v_2 = \sqrt{2gh_1} = \sqrt{2(9.8)20}$$

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

12. A block of mass 0.33 kg rests against a spring with spring constant 1100 N/m as shown below. This spring is compressed a distance 0.12 m, and then released. Find the speed of the mass when it leaves the spring. Assume that all friction is negligible.

(a) ~~400 m/s~~

→ (b) 6.9 m/s

(c) 58 m/s

(d) 11 m/s

(e) 2.8 m/s

$$\tfrac{1}{2}mv^2 = \tfrac{1}{2}kx^2$$

$$v = \sqrt{\frac{k}{m}x^2} = \sqrt{\frac{1100}{0.33}\cdot(0.12)^2}$$

$$= 6.9 \text{ m/s}$$

The End