Name ______________________________________ Section ____________

Physics 1210 Exam #2
October 26, 2017

This test is closed-note and closed-book. No written, printed, or recorded material is permitted. Calculators are permitted but computers are not. No collaboration, consultation, or communication with other people (other than the administrator) is allowed by any means, including but not limited to verbal, written, or electronic methods. Sharing of calculators is prohibited. If you have a question about the test, please raise your hand. For multiple choice, you may choose two answers, and if one is correct, receive half credit, etc. For full credit on written problems, show the full thought process from basic equations to final results.

$$V_{sphere}=\frac{4}{3}\pi R^3$$

$$V_{avg}=\frac{x_2-x_1}{t_2-t_1}=\frac{\Delta x}{\Delta t} \quad a_{avg}=\frac{v_2-v_1}{t_2-t_1}=\frac{\Delta v}{\Delta t} \quad a_{centrip}=\frac{v^2}{R}=\frac{4\pi^2 R}{T^2}$$

$$2.2\,lbs=1\,kg \qquad 1\,mi=5280\,ft=1609\,m \qquad 1\,Calorie=4200\,J$$

$$x_1=x_0+v_0t+\frac{1}{2}at^2 \quad v_1=v_0+at \quad v_1^2=v_0^2+2a(x_1-x_0)$$

$$x_{quadratic}=\frac{-b\pm\sqrt{b^2-4ac}}{2a}$$

Work/Energy $\Sigma\bar{F}=m\bar{a} \quad F_{spring}=-kx \quad F_f=\mu F_n$

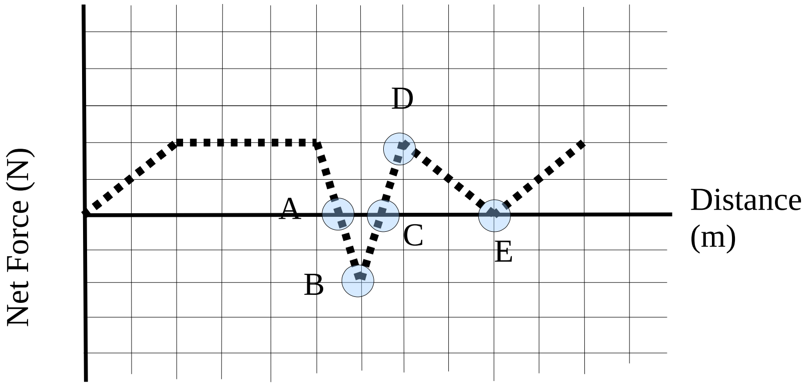
$$W=\bar{F}\cdot\bar{s} \quad W=\Delta K \quad K=\frac{1}{2}mv^2 \quad U_s=\frac{1}{2}kx^2 \quad U_g=mgy \quad P=\frac{\Delta W}{\Delta t}=Fv \quad W_{grav}=-\Delta U \quad F=-\frac{dU}{dx}$$

Momentum/Impulse

$$p=mv \quad J=\Delta(mv)=Ft \quad X_{cm}=\frac{\Sigma m_i x_i}{\Sigma m_i}$$

1. (10 pts) Consider the Force versus Position diagram at right. A stable equilibrium would be located nearest the circled region

[✓ A. A] B. B C. C D. D E. E



2. (10 pts) For most common frictional forces

A. $\mu_k < \mu_s$ and $\mu_k > 1$

B. $\mu_k > \mu_s$ and $\mu_k > 1$

[✓ C.] $\mu_k < \mu_s$ and $\mu_k < 1$

D. $\mu_k > \mu_s$ and $\mu_k < 1$

E. $\mu_k = \mu_s$ and $\mu_k > 1$

3. (10 pts) A 50 kg student in an elevator is standing on a scale that reads 600 Newtons. From this she can conclude she is:

A. moving upward B. moving downward C. stationary D. accelerating downward [✓ E.] accelerating upward

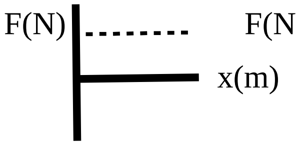
4. (10 pts) A person jumps out of a plane and eventually reaches a constant "terminal" velocity due to air drag. At this velocity

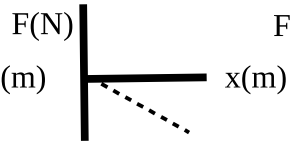
A. his speed is equal to g B. the force of drag is equal to zero [✓ C.] the force of air drag is equal to his weight D. his acceleration is equal to g E. the force of air drag on him is equal to g

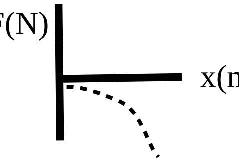
5. (10 pts) A stock person at a grocery store has a job consisting of the following five segments: (1) picking up boxes of fruit from the floor; (2) accelerating forward to a comfortable speed; (3) carrying the boxes to a display stand at constant speed; (4) decelerating to a stop; (5) lower the boxes slowly to the floor. During which of the five segments does the person do positive work?

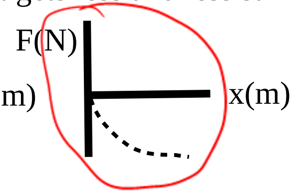
A. 1 only [✓ B.] 1 and 2 only C. 1,2,4,5. D. 2 and 3 only E. 1 and 5 only

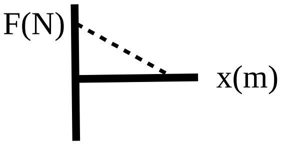
6. (10 pts) Which graph illustrates a "non-ideal" spring that gets less and less stiff the more it is stretched?











7. (10 pts) Write a few lines of Matlab code that would plot the elastic potential energy stored in an ideal spring with k=10 N/m every 0.5 meters from x=-2 to 2 meters.

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k=10
X= -2:0.5:2
U=0.5*k*X.**2
plot(X,U)
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8. (10 pts) Is it possible for an object to have negative gravitational potential energy?

A. Yes, as long as the total energy is positive
B. No, because this would have no physical meaning
C. Yes, as long as the kinetic energy is positive
D. No, because the kinetic energy of an object must equal is potential energy
[✓ E.] Yes, because the choice of zero potential energy is arbitrary.

9. (10 pts) If the potential energy of a molecule at position x is described by U(J)=3x^2 - 4x , the force on the molecule at x=-2 is

A. zero B. 20 J C. -20 J [✓ D.] 16 J E. -16 J

$F = -\frac{du}{dx} = -(6x-4)$
$= -(6(-2)-4) = 16$

10. (10 pts) A truck of mass M moving at speed V locks its brakes and skids to a stop in time t. The coefficient of friction is μ between the tires and road. If you double the truck's initial speed, double its mass, and double μ, the new stopping time is [✓ A.] unchanged B. 1/2 t C. 1/4 t D. 2t E. 4t

$J = \Delta P = F_f t = \mu \cancel{m} g t = \cancel{M} V$
$t = \frac{V}{\mu g}$ so doubling V and μ leaves t unchanged.

11. (10 pts) In a perfectly elastic collision between two rigid objects

A. the kinetic energy of each object is conserved.
B. the momentum of the system is conserved but the kinetic energy of the system is not conserved.
[✓ C.] both the momentum and kinetic energy of the system are conserved.
D. the momentum of each object is conserved.
E. the kinetic energy of the system is conserved but the momentum of the system is not conserved.

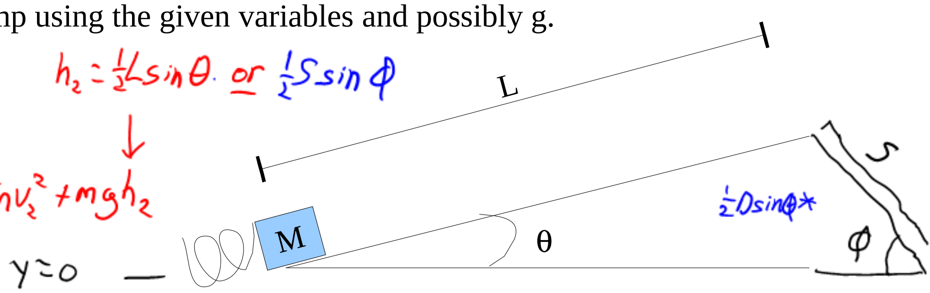
12. (10 pts) Describe an activity that a 50 kg human could (briefly!) do that would require 500 Watts of power. Show a short calculation to back up your claim.

$500\text{ W} = 500 \frac{J}{s}$ So lifting body weight off 500N in 1sec

13. (40 pts) A box of mass M is compressed against a spring at the bottom of a ramp of length L and angle θ above the horizontal. The spring is compressed a distance D from compared to its relaxed zero-compression length. The coefficients of friction between the box and ramp are μ_s and μ_k. Give an expression for the velocity, V, of the box when it reaches the top of the ramp using the given variables and possibly g.

$E_1 = E_2$

$h_2 = \frac{1}{2} L \sin\theta$. or $\frac{1}{2} S \sin\phi$



$$\cancelto{0}{K_1} + \cancelto{0}{U_{g_1}} + U_{sp_1} + W_0 = K_2 + U_{g_2} + \cancelto{0}{U_{sp_2}}$$

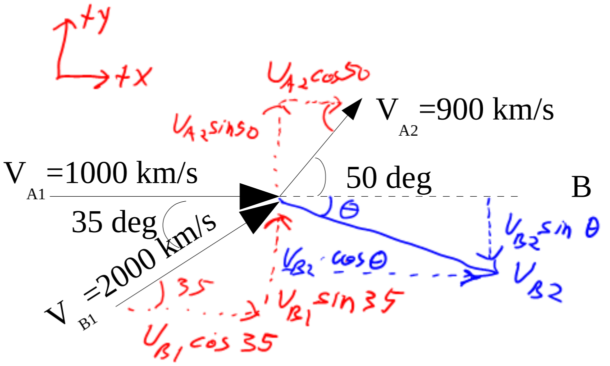
$$\frac{1}{2}kD^2 + \underbrace{\left(-\mu_{k_1} mg\cos\theta L - \frac{1}{2}\mu_{k_2} mg S\cos\phi\right)}_{W_0} = \frac{1}{2}mV_2^2 + mgh_2$$

$$\frac{1}{2}kD^2 - \mu_{k_1} mgL\cos\theta - \frac{1}{2}\mu_{k_2} mgS\cos\phi - mg\frac{1}{2}L\sin\theta = \frac{1}{2}mV_2^2$$

multiply by 2 and divide by m on both sides

$$\sqrt{\frac{k}{m}D^2 - gL\sin\theta - g(2\mu_{k_1}L\cos\theta + \mu_{k_2}S\cos\phi)} = V_2$$

14. (40 pts) Two satellites M_A=4 Mg and M_B=5 Mg (mass in mega grams) collide in space at the indicated initial velocities and angles. The final direction and speed of satellite A is shown. Find the magnitude and direction of V_{B2}, the velocity of satellite after the collision, relative to the dotted line.



Conserve momentum in X and Y

X

$P_1 = P_2$

$M_A V_{A1} + M_B V_{B1}\cos 35 = M_A V_{A2}\cos 50 + M_B V_{B2}\cos\theta$

Y

$P_1 = P_2$

$M_B V_{B1}\sin 35 = M_A V_{A2}\sin 50 + M_B V_{B2}\sin\theta$

V_{B2} and θ are unknown; You can use $M_A = 4$, $M_B = 5$ $V_{A1} = 1$ $V_{B1} = 2$ $V_{A2} = 0.9$

$M_A V_{A1} + M_B V_{B1}\cos 35 - M_A V_{A2}\cos 50 = M_B V_{B2}\cos\theta$

$4\cdot 1 + 5\cdot 2\cos 35 - 4\cdot 0.9\cos 50 = M_B V_{B2}\cos\theta$

$9.87 = M_B V_{B2}\cos\theta$

$M_B V_{B1}\sin 35 - M_A V_{A2}\sin 50 = M_B V_{B2}\sin\theta$

$5\cdot 2\sin 35 - 4\cdot 0.9\sin 50 = M_B V_{B2}\sin\theta$

$2.97 = M_B V_{B2}\sin\theta$

Divide Right by left

$$\frac{2.97}{9.87} = \frac{M_B V_{B2}\sin\theta}{M_B V_{B2}\cos\theta} = \tan\theta \rightarrow \theta = 16.7^\circ$$

Back substitute to find V_B

$2.97 = 5\cdot V_{B2}\sin 16.7$

$\frac{2.97}{5\sin 16.7} = V_{B2} = 2.06$ or 2060 km/s

angle is north of East.

Test by comparing Y momenta

Y

$P_{iy} = P_{fy}$

$M_B V_{B1}\sin 35 = M_A V_{A2}\sin 50 + M_B V_{B2}\sin 23$

$5\cdot 2000\sin 35 = 4\cdot 900\sin 50 + 5\cdot 2060\sin 16.7$

$5735\ \mathrm{Kg}\frac{m}{s} = 2757 + 2962$

$\uparrow$ equates!