PHY 201 Final Exam Name ____________________

Instructions:
1. Do all of your work in this booklet.
2. **Show all of your steps** in problems for full credit.
3. **Be clear and neat** in your work. Any illegible work, or scribbling in the margins, will not be graded.
4. Place your **answers in a box.**
5. If you need more space, you may use the back of the page and write **On back** in the problem space.

Page	Score
1 20 pts	
2 60 pts	
3 60 pts	
4 60 pts	
Total 200 pts	

1. **Multiple Guess (20 pts)** Find the answer which best fits the question and write it in the space provided.

Key Ignore

a. Doubling the intensity increases the intensity level
a) 3 dB b) 5 dB c) 10 dB d) 20 dB
~~a~~

b. You are told that a car completes one lap on a circular track in 18.9 s. From this information one can find
a) the tangential velocity; b) the angular velocity;
c) the angular acceleration; d) the radius of the track;
b

c. The average and instantaneous speeds of an object are equal when the object
a) has uniform velocity. b) has uniform acceleration.
c) moves in a straight line. d) covers twice as much distance in each second. e) none of the above.
a

d. Increasing the mass at the end of a simple pendulum will
a) increase the frequency b) decrease the period c) increase the period d) have no effect on the period or frequency.
~~d~~ Ignore

e. As a general rule, friction
a) depends on the surface area; b) is proportional to the normal force; c) depends on the sliding speed; d) is greater for smoother surfaces; e) none of the above.
b

f. Cars moving on a properly banked track remain on the track because of the
a) friction. b) centripetal force. c) normal force.
d) gravitational force between the road and the car.
c

g. A hoop, a solid cylinder and a sphere of equal radii are placed at the top of an incline. They are released at the same time. Which one reaches the bottom last?
a) hoop; b) cylinder; c) sphere; d) One cannot tell.
a

h. The superposition of waves producing a composite wave of greater amplitude than any of the individual waves is
a) constructive interference b) destructive interference
c) reflection d) harmonic motion
a

i. Spontaneous heat flow from a colder body to a warmer body is in violation of the
a) first law b) second law c) third law d) zeroth law
b

j. In an inelastic collision what is conserved?
a) energy b) mass c) velocity d) momentum
d

k. As an ambulance drives away from an observer, the siren frequency will
a) stay the same. b) increase. c) decrease.
c

l. Car J moves twice as fast as car K, and car J has half the mass of car K. The kinetic energy of car J is ________ the kinetic energy of car K.
a) the same as; b) twice; c) four times; d) half;
b

m. A baseball player follows through with his swing to
a) conserve momentum; b) ensure an elastic collision;
c) make the contact time with the ball as short as possible;
d) increase the impulse imparted to the ball; e) none of the above.
d

n. Pressure applied to an enclosed fluid is transmitted in all directions to every portion of the fluid. This effect is known as
a) Bernoulli's Principle; b) Pascal's Principle;
c) Archimedes' Principle; d) Newton's Principle
b

o. The constant G in Newton's Law of Gravitation
a) depends upon the acceleration due to gravity; b) applies only if the Earth is one of the masses; c) is fixed by the mass of the moon; d) is a universal constant of nature.
d

p. When a person, riding on a Ferris wheel, makes one complete revolution from the bottom and back, the net work done by the gravitational force is
a) positive b) zero c) negative.
b

q. The first harmonic in a stretched string of length L has a wavelength of
a) L/2 b) L c) 2L d) 3L d) 4L
c

r. On which of the following is the moment of inertia of a body not dependent?
a) its shape; b) its velocity c) the distribution of mass;
d) its rotation axis; e) none of these.
b

s. If an object displaces an amount of liquid of greater weight than its own, the object will
a) float b) sink c) remain in equilibrium for any submerged position.
a

t. If the length of a simple pendulum is doubled, then its period
a) doubles. b) halves. c) is less by a factor of $\sqrt{2}$.
d) is greater by a factor of $\sqrt{2}$. e. remains the same.
d

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Constants:
R = 8.31 J/(mol K); $\sigma = 5.67\times10^{-8}$ J/(s m^2 K^4); 1 kcal = 4186 J; Water: L_f = 80 cal/g; L_v = 540 cal/g; Density of Ice = 917 kg/m^3; 6.67×10^{-11} Nm^2/kg^2; $M_E = 5.98\times10^{24}$ kg; $R_E = 6.38\times10^3$ km; Formula masses: C:12, O:16.

a. Let the force exerted on a body be given as $F(x) = 2x + 5$ N. Determine the work done by this force to move the body from $x = 1.0$ m to $x = 3.0$ m.

$W = \int_1^3 (2x+5)\,dx = x^2+5x\Big|_1^3 = \boxed{18\,J}$

b. How much ice at 0.0 °C must be added to 300 g of water at 100.0°C so as to end up with all liquid at 50.0°C?

$300(50)1 = 80m + 50m$

$m = \boxed{115g}$

c. A motor lifts a 500.0 kg elevator at a constant speed through a distance of 20.0 m in a time of 30.0 seconds. What is the average power expended by the motor?

$P = \frac{500(9.8)20}{30} = \boxed{3270W}$

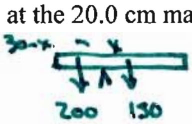
d. A car sitting in the sun heats up and radiates 952 watts per square meter of surface area. Assuming that it behaves like a blackbody, find its temperature.

$952 = \sigma T^4 \Rightarrow T = \boxed{360K}$

e. A 30.0 cm long piece of wire lengthens 1.62 mm when heated from 20°C to 300°C. What is the coefficient of linear thermal expansion for the material of the wire?

$\alpha = \frac{1.62\times10^{-3}}{280(.3)} = \boxed{1.93\times10^{-5}\ (^\circ C)^{-1}}$

f. Find the pivot position at which to balance a system consisting of a 150 g uniform meter stick with a 200 g block tied to the stick at the 20.0 cm mark.



$(30-x)200 = 150x$

$30(200) = 350x$

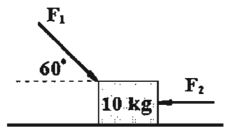
$x = 17 \Rightarrow \boxed{33\text{ cm mark}}$

g. A 3.0 g penny is dropped from the top of the Sears Tower, a height of 443.0 m above the ground. How fast is it moving when it hits the ground?

$v^2 = 2gh$

$v = \sqrt{2(9.8)443} = \boxed{93\,m/s}$

h. Two forces act on a 10.0 kg block as shown below. The magnitudes of the forces are $F_1 = 30.0$N and $F_2 = 20.0$N. What is the horizontal acceleration of the block?



$ma = -20 + 30\cos 60 = -5$

$a = \boxed{-0.5\,m/s^2}$

i. In a hydraulic system the input area is 3.0 cm^2 and the output is 15.0 cm^2. If the input force is 50.0 N, what is the output force?

$F_2 = \frac{A_2}{A_1}F_1 = \boxed{250N}$

j. Consider $\mathbf{r} = (-2.5t + 1.5)\mathbf{i} + (3.1t^2 - 2.2t + 1.3)\mathbf{j}$ in meters.

i. Find $\mathbf{r}_0$ and $\mathbf{v}_0$.

$\vec{r}_0 = 1.5\hat{i} + 1.3\hat{j}$

$\vec{v}_0 = -2.5\hat{i} - 2.2\hat{j}$

ii. What is the acceleration?

$\vec{a} = 6.2\hat{j}$

k. The second harmonic of a string held firmly at its two ends resonates at 150.0 Hz. If the string is 30.0 cm long, then what is wave speed of the vibration in the string?

$f_2 = \frac{2v}{2L} = \frac{v}{L}$

$v = 30(150) = \boxed{45\,m/s}$

l. A 100.0N force is applied tangentially to the edge of a solid disk with mass 30.0 kg and radius 0.200 m. What is the resulting angular acceleration?

$Fr = I\alpha$

$\alpha = \frac{2F}{mr} = \boxed{33\,rad/s^2}$

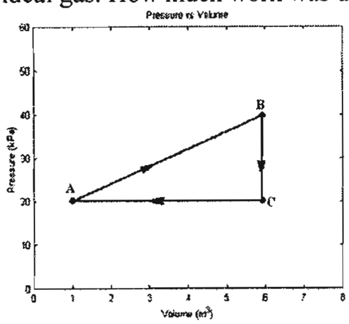
a. What is the pressure on a diver 20.0 m below the surface of a lake at sea level? (Give the answer in atmospheres.)

$P = P_0 + \rho g h$

$= 1 + 10^3(9.8)20 / 1.013\times10^5$

$= \boxed{2.93\,\text{atm}}$

b. . The PV diagram (m^3 vs kPa) is shown below for a particular ideal gas. How much work was done in the process



i. A to B?

$\boxed{150\,\text{KJ}}$

ii. Over cycle the ABCA?

$\boxed{50\,\text{KJ}}$

iii. How much heat energy was exchanged during the cycle?

$0 = \Delta U = Q - W \Rightarrow Q = \boxed{50\,\text{KJ}}$

c. Convert 20.0 m/s to miles per hour. (1 mi = 1.609 km)

$20\frac{m}{s} \cdot \frac{3600}{1}\frac{s}{h} \cdot \frac{1\,mi}{1609\,m} = \boxed{44.7\,\text{mph}}$

d. A ball begins to roll up an inclined plane without slipping at a translational speed of 5.0 m/s. How high does the ball get before turning around? Assume there is no energy loss.

$\frac{7}{10}mv^2 = mgh \Rightarrow h = \frac{7v^2}{10g} = \boxed{1.79\,m}$

e. A student, in a hurry to go home after, leaves her book on top of the car. She drives around a flat curve with a 70 m radius. If the coefficient of static friction between the book and the car is 0.10, what is the maximum speed the car can have without the book sliding off?

$v = \sqrt{\mu_s r g} = \boxed{8.3\,m/s}$

f. A 12000 kg railroad car traveling at 10 m/s strikes and couples with a 6000 kg caboose at rest. What is the speed of the final combination?

$12000 \cdot 10 = 18000\,V$

$V = \boxed{6.7\,m/s}$

g. Consider a CO_2 molecule.

i. What is its mass in kilograms?

$m = \frac{44\times10^{-3}\,kg}{6\times10^{23}} = \boxed{7.3\times10^{-26}\,kg}$

ii. What is its average speed at 20 °C?

$v = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3(8.31)293}{.044}} = \boxed{407\,m/s}$

h. A figure skater is spinning with an angular velocity of 15 rad/s. She then comes to a stop over a brief period of time. During this time, her angular displacement is 5.1 rad. How long did it take her to stop.

$t = \frac{\theta}{\bar{\omega}} = \frac{5.1}{7.5} = \boxed{0.68\,s}$

i. An inventor claims to have developed a heat engine that, on each cycle, takes in 120 kcal of heat from a high-temperature reservoir at 400°C and exhausts 50 kcal to the surroundings at 25°C. Compute the efficiency and Carnot efficiency to answer. Would you invest your money in the production of this engine?

$e = 1 - \frac{50}{120} = 58\%$

$e_c = 1 - \frac{298}{673} = 56\%$ $\boxed{\text{No}}$

j. A 62.0 kg person dives straight down into the water. Just before striking the water, her speed is 5.50 m/s. During a time of 1.65 s her speed in the water is reduced to 1.10 m/s. What is the average net force on her when she hits the water?

$\vec{F} = \frac{\Delta p}{\Delta t} = \boxed{165\,N}$

k. A jetliner lands with a speed of 69.0 m/s. What average acceleration is needed for it to land on a 750.0 m runway while reducing its speed to 6.10 m/s?

$a = \frac{v^2 - v_0^2}{2x} = \frac{6.1^2 - 69^2}{1500} = \boxed{-3.1\,m/s^2}$

l. A simple pendulum has a length of 25.0 cm. What is the period of oscillation?

$T = 2\pi\sqrt{\frac{L}{g}} = \boxed{1.0\,s}$

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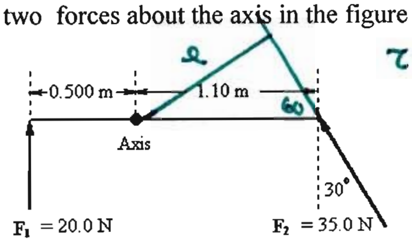
a. Find the net torque (magnitude and direction) produced by the two forces about the axis in the figure below.

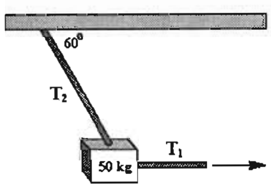


$\tau = -20(.5) + 35(1.1)\sin 60$

$= \boxed{23.3 \text{ Nm}}$

CCW

b. A block is suspended on a rope and pulled to the right using another rope as shown below. Find the tensions in the ropes to maintain equilibrium.



$T_1 = T_2 \cos 60$

$T_2 \sin 60 = 50(9.8)$

$T_2 = \boxed{565 \text{ N}}$

$T_1 = \boxed{283 \text{ N}}$

c. An ideal gas in a 1000 cm^3 container has a temperature of 100 °C and a pressure of 150 kPa. If the gas is now compressed to a volume of 250 cm^3 at a temperature of 200°C, what is the new pressure in the container?

$P_2 = \frac{V_1}{V_2} \frac{T_2}{T_1} P_1$

$= \frac{1000}{250} \frac{473}{373} 150 = \boxed{761 \text{ kPa}}$

d. Which process has a greater change in entropy magnitude: 120 g of ice changing to water at 0 °C, or 30 g of steam condensing to water at 100 °C? [Compute the entropy in each case and compare!]

$\Delta S = \frac{\Delta Q}{T} = \frac{120(80)}{273} = 35 \text{ cal/K}$

$\Delta S = \frac{\Delta Q}{T} = \frac{30(540)}{373} = 43 \text{ cal/K}$ ⟸ steam

e. A bullet is fired from a rifle that is held 1.6 m above the ground in a horizontal position. The initial speed of the bullet is 1100 m/s. How far does the bullet travel forward before hitting the ground?

$t = \sqrt{2(1.6)/g} = 0.57 \text{ s}$

$x = \boxed{628 \text{ m}}$

f. Mars has a mass of 6.46×10^{23} kg and a radius of 3.39×10^{6} m. How much would a 75 kg person weigh on Mars?

$F = \frac{(6.67 \times 10^{-11})(75)(6.46 \times 10^{23})}{(3.39 \times 10^{6})^2} = \boxed{281 \text{ N}}$

g. An oscillator consists of a block of mass 0.250 kg connected to a spring. When set into oscillation with amplitude of 20.0 cm, it is observed to repeat its motion every 0.250 s. What is the

i) frequency of oscillation 4.0 Hz

ii) spring constant. 158 N/m

iii) maximum speed. 502 cm/s = 5.02 m/s

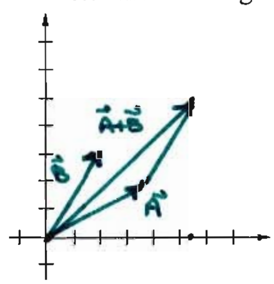
h. Consider the two vectors:

A has magnitude 4.0, oriented 30° to the x-axis.

B has an x-component of 2.0 and a y-component of 3.0.

i. Sketch and label **A, B** and **A+B**.

ii. Determine the magnitude and direction of **A+B**.



$A_x = 4.0\cos 30 = 3.46$

$A_y = 4.0 \sin 30 = 2.00$

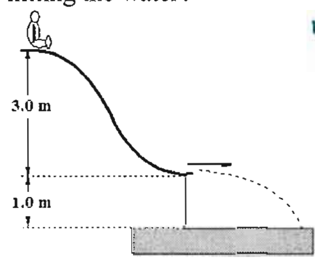
$C_x = 3.46 + 2 = 5.5$

$C_y = 2.00 + 3.0 = 5$

$C = \boxed{7.4}$

$\theta = \tan^{-1}(\frac{5}{5.5}) = \boxed{42°}$

i. A 40.0 kg kid coasts down a frictionless water slide from rest and lands in the water below. How fast is he moving just before hitting the water?



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

$v = \sqrt{2gh} = \boxed{8.85 \text{ m/s}}$

j. A 0.45 kg golf ball at rest is hit horizontally with a club and attains a speed of 41.0 m/s. The club is in contact with the ball for 0.010 m. Use the Work-Energy Theorem to find the average force exerted by the club.

$\vec{F} = \frac{\frac{1}{2}mv^2}{.01} = \boxed{37800 \text{ N}}$

k. The intensity of sound is 35.0 W/m^2 two meters from a source. What is the intensity 5.0 meters from the source?

$I_2 = I_1 \left(\frac{r_1}{r_2}\right)^2 = 35\left(\frac{2}{5}\right)^2 = \boxed{5.6 \text{ W/m}^2}$

l. Let $\mathbf{r} = 3\mathbf{i} - 5\mathbf{j}$ m and $\mathbf{p} = 2\mathbf{i} + 4\mathbf{k}$ kg m/s. Compute $\mathbf{r} \times \mathbf{p}$.

$\vec{r} \times \vec{p} = -12\hat{j} + 10\hat{k} - 20\hat{i}$

Bonus Problems and extra space

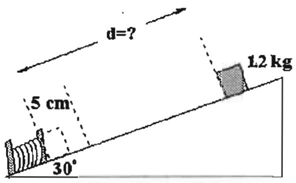
a. A golf ball leaves a tee with an initial velocity of 30.0 m/s at an angle of 45°. What is the maximum height reached by the ball?

$v_{0x}=v_{0y}=30\frac{\sqrt{2}}{2}=21.2$ m/s

$0=v_y=v_{0y}-gt \Rightarrow t=2.16$ s

$y=v_{0y}t-\frac{1}{2}gt^2=$ **23 m**

b. A 1.20 kg block slides down the incline shown and compresses a spring 5.0 cm as it comes to rest. If the spring constant is 1.00×10^3 N/m, what distance d did the block travel?



$\frac{1}{2}kx^2=mgh=mgd\sin\theta$

$d=\frac{\frac{1}{2}(1000)(.05)^2}{1.2(9.8)\sin 30}$

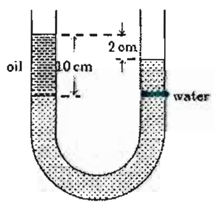
$=$ **21 cm**

c. Water flows through a garden hose at 11 cm/s. The circular hose has a radius of 1.5 cm and the hose nozzle has a radius of 0.25 cm. What is the water speed in the nozzle?

$A_1v_1=A_2v_2$

$v_2=\frac{A_1}{A_2}v_1=\left(\frac{1.5}{.25}\right)^2 11=$ **3.96 m/s**

d. Determine the density of the oil in the U-tube.



$\rho_o g\,10=\rho_w g\,8$

$\rho_o=$ **800 kg/m³**

e. $y(x,t)=3.00\sin(2.0x+8.0t)$ describes a wave, where x is in meters, y is in centimeters, and t is in seconds. Find the

i. amplitude 3.00 cm

ii. wavelength 3.14 m

iii. wave speed 4.0 m/s

f. The temperature of 2.0 moles of a monatomic ideal gas is increased from 150°C to 250°C. If 2000 J of heat energy was added to the system, then what work was done in this process?

$\Delta U=Q-W$

$W=Q-\Delta U$

$=2000-\frac{3}{2}nR\Delta T$

$=2000-3(8.31)100$

$=$ **−493 J**