FINAL EXAM – v1

PHYS 201 (Spring 2018), 05/03/18

Name: Solution Key

Lab-Sect. no.:

Signature:

In taking this exam you confirm to adhere to the Aggie Honor Code:
"An Aggie does not lie, cheat, steal or tolerate those who do."

Duration: 120 minutes
Show all your work for full/partial credit!
Include the correct units in your final answers for full credit!
Unless otherwise stated, quote your results in SI units!

1.) *Multiple Choice* *(14 pts.)*

For each statement below, circle the correct answer (A, B or C, no reasoning required).

(a) If the speed of a car doubles, it's stopping distance (at constant deceleration) increases by a factor of
(A) 2 (B) 4 (C) 8.

(b) In projectile motion, the acceleration at the highest point of the trajectory is
(A) zero (B) pointing down (C) pointing forward.

(c) In uniform circular motion, the acceleration vector
(A) is constant (B) keeps changing its direction (C) keeps changing its magnitude.

(d) The apparent weight of a person standing in a downward accelerating elevator is
(A) smaller than (B) equal to (C) larger than
the person's real weight.

(e) When you increase the length of a pendulum, it's oscillation frequency
(A) increases (B) stays constant (C) decreases.

(f) The heat required to increase the temperature of 1 kg of water from 1 to 99°C is
(A) larger than (B) equal to (C) smaller than
the heat required to convert 1 kg of water at T=99.9°C into steam at T=100.1°C.

(g) When adding heat to an ideal gas at constant volume, the temperature increase is
(A) larger than (B) equal to (C) smaller than the temperature increase when adding the same amount of heat at constant pressure.

No.	Points
1	
2	
3	
4	
5	
6	
7	
8	
Sum	

2.) *1-D Kinematics* *(15 pts.)*

Starting from rest, a car drives at constant acceleration, covering 15 m in the first 3 seconds.

(a) How far does it travel during the following 3-second interval?

(b) How fast is it moving after the first 6 seconds?

(c) What is its acceleration?

(a) $x_1 = \frac{1}{2} a t_1^2$

$x_2 = \frac{1}{2} a t_2^2$

$t_2 = 2t_1 \Rightarrow x_2 = 4x_1$

$\Rightarrow \boxed{\Delta x_2 = x_2 - x_1 = 45m}$

(b) $\bar{v} = \frac{\Delta x}{\Delta t} = \frac{60m}{6s} = 10 m/s$

$\Rightarrow \boxed{v_f = 2\bar{v} = 20 m/s}$

(c) $\boxed{a = \frac{\Delta v}{\Delta t} = \frac{20}{6} = 3.3 m/s^2}$

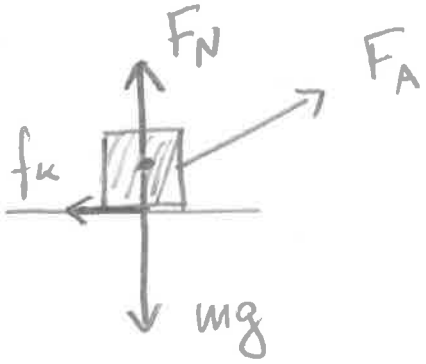
3.) *Newton's 2. Law* *(12 pts.)*

A worker applies a force of 180 N, at an angle of 33° above the horizontal, on a box of mass 45 kg on a horizontal surface. The box starts sliding; the kinetic friction coefficient between the box and surface of 0.28.

(a) Draw a free-body diagram of the box.

(b) What is the acceleration of the box?

(a)



(b) $ma_x = F_{A_x} - f_K = F_A \cos\theta - \mu_K F_N$

$0 = ma_y = F_N - mg + F_A \sin\theta$

$\Rightarrow F_N = mg - F_A \sin\theta$

$\Rightarrow ma_x = F_A \cos\theta - \mu_K (mg - F_A \sin\theta)$

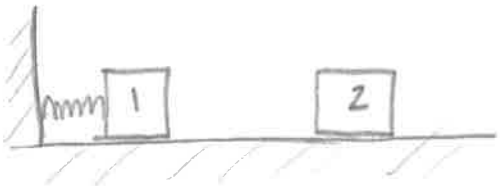
$$\boxed{a_x = \frac{F_A}{m}(\cos\theta + \mu_K \sin\theta) - \mu_K g = 0.78 \ \frac{m}{s^2}}$$

4.) *Elastic Potential Energy and Collsions* *(12 pts.)*

A box of mass $3\,kg$ is pushed against a horizontal spring, compressing it by $40\,cm$. After release, the box slides along a horizontal frictionless surface and collides with another box of mass $5\,kg$. After the collision, the boxes stick together moving at a speed of $1.6\,m/s$.

(a) What was the speed of the first box just before colliding with the second box?

(b) How large is the spring constant?



(a) $(m_1 + m_2)\, v_{12} = m_1 v_1$

$$\Rightarrow \boxed{v_1 = \frac{m_1+m_2}{m_1} v_{12} = 4.27\ \frac{m}{s}}$$

(b) $E_0 = E_1$

$$\frac{1}{2}kx^2 = \frac{1}{2} m_1 v_1^2$$

$$\Rightarrow \boxed{k = m_1 \frac{v_1^2}{x^2} = 341\ \frac{N}{m}}$$

5.) *Rolling Motion* *(6+6+3pts.)*

A uniform cylinder ($I=\frac{1}{2}mr^2$) of mass $0.3\,kg$ and radius $0.05\,m$, starting from rest, is rolling down an inclined plane of vertical height $0.2\,m$ at constant acceleration. The plane is inclined at an angle of 20° above the horizontal. Neglect any friction losses.

(a) What are the translational and angular speed of the cylinder at the bottom of the plane?

(b) What is the cylinder's angular acceleration?

(c) What is the net torque acting on the cylinder?

(a) $E_0 = E_f$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{1}{2}mr^2\right)\left(\frac{v}{r}\right)^2$$

$$= \frac{3}{4}mv^2$$

$$\Rightarrow \boxed{v = \sqrt{4/3\,gh} = 1.62\ m/s}$$

$$\boxed{\omega = \frac{v}{r} = 32.3\ rad/s}$$

(b) $\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$, $\Delta\theta = \frac{s}{r} = \frac{h}{r\sin\theta}$

$$\Rightarrow \boxed{\alpha = \frac{\omega^2}{2}\frac{r\sin\theta}{h} = 44.7\ \frac{rad}{s}} \qquad s = \frac{h}{\sin\theta}$$

(c) $\boxed{\tau = I\alpha = 0.017\ Nm}$

6.) *Wave Description* *(8 pts.)*

A transverse wave is described by the equation

$$y(t,x) = 30\,cm\ \sin[t/0.25s - x/20cm]$$

(a) Calculate the wavelength and frequency of the wave.

(b) Determnine the amplitude and propagational speed of the wave.

(a) $\frac{2\pi}{\lambda} = \frac{1}{20cm} \Rightarrow \boxed{\lambda = 2\pi \cdot 0.2m = 1.26\,m}$

$2\pi f = \frac{1}{0.25s} \rightarrow \boxed{f = \frac{1}{2\pi}\,4\,Hz = 0.64\,Hz}$

(b) $\boxed{A = 0.3m}$

$\boxed{v = f\lambda = 0.8\,\frac{m}{s}}$

7.) *Ideal Gas* *(15 pts.)*

Two moles of an ideal monatomic gas are held at an initial temperature and volume of $290\,K$ and $0.02\,m^3$. The average speed of the ~~molecules~~ particles is measured to be $600\,m/s$.

(a) What is the initial pressure of the gas?

(b) What is the mass of the gas ~~molecules~~ particles, in units of the atomic mass unit $u = 1.66 \cdot 10^{-27} kg$?

(c) The gas now expands at constant temperature (isothermally) to twice it's original volume. How much work does the gas do?

(a) $pV = nRT \Rightarrow \boxed{p_i = \frac{nRT_i}{V_i} = 2.41 \cdot 10^5\,Pa}$

(b) $\frac{1}{2} m \bar{v}^2 = \frac{3}{2} kT$

$\Rightarrow \boxed{m = 3\frac{kT}{\bar{v}^2} = 3.3 \cdot 10^{-26} kg * \frac{1u}{1.66 \cdot 10^{-27} kg} = 20\,u}$

(Neon)

(c) $W = nRT \ln\left(\frac{V_2}{V_1}\right)$

$\boxed{W = 3341\,J}$

8.) *Buoyancy* *(10 pts.)*

Two cowboys construct a wooden raft to transport goods on the Brazos river. They use cedar wood with its relatively low specific density of $\rho_{wood}/\rho_{water}=0.45$. The raft has a horizontal area of $4\,m^2$ and a vertical thickness of $8\,in$ ($1\,in=2.54\,cm$).

(a) If the raft floats in water without any load, how many cm's will it protrude above the water level?

(b) What is the maximal load (in kg) that can be put on the raft before it is completely submerged?

(a) $F_B = mg$

$\rho_{fl} V_{sub} g = \rho_{obj} V_{obj} g$

$\Rightarrow V_{sub} = V_{obj} \frac{\rho_{obj}}{\rho_{fl}} = 0.45\, V_{obj}$

$\Rightarrow V_{above} = 0.55\, V_{obj}$

$\boxed{h_{above} = 0.55\, h = 4.4\,in = 11.2\,cm}$

(b) $F_B = (m + M_{load})\, g$

$\rho_{fl} V_{obj} g = (m + M_{load})\, g$

$\Rightarrow \boxed{M_{load} = \rho_{fl} V_{obj} - m = 447\,kg}$