College Physics 1 Final

PHYS 1511

12/12/2016

Professor Halekas

Form A

(Put this letter on your scantron!)

Directions for completing your answer sheet

1. Use a no. 2 or softer **PENCIL**. Marks should be dark and completely fill each circle. Carefully erase any marks you want to change. Do not make any stray marks on your answer sheet.

2. Print your name in the appropriate boxes and darken the corresponding circles.

3. Record all 8 digits of your University ID number starting in box A under "**ID NUMBER**" and darken the corresponding circles. **Be sure you start in box A.**

4. Note the letter following the word **FORM** in the box at the top of this page and darken the corresponding letter in the **TEST FORM** area of your answer sheet.

5. Mark only one response for each test item.

FAILURE TO FOLLOW THE ABOVE DIRECTIONS COULD RESULT IN AN INCORRECT SCORE

READ THE FOLLOWING AND PROVIDE YOUR SIGNATURE:

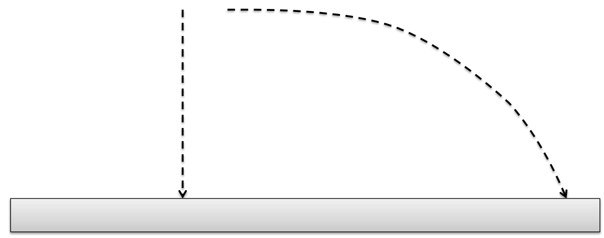
I understand that sharing information with anyone during this exam by talking, looking at someone else's test, or any other form of communication, will be interpreted as evidence of cheating. I also understand that if I am caught cheating, the result will be no credit (0 points) for this test, and disciplinary action may result.

Signature: ____

Print your name: ____

(This will help identify your test paper in the event of any scoring issues)

Question 1: My son Arlo was playing with two bouncy balls yesterday. He threw one ball with a horizontal initial velocity, and simultaneously dropped the other ball from rest from the same initial height. Assuming air resistance was negligible, which ball hit the floor first?

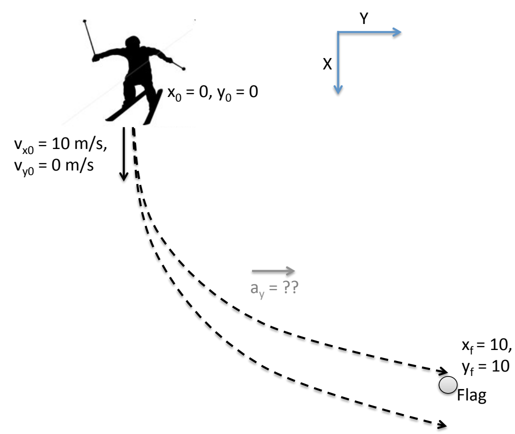


A. The ball thrown horizontally
B. The ball dropped vertically
C. Both balls took the same time to hit the floor
D. There is insufficient information to answer the question

Question 2: A drag racer starts from rest and accelerates steadily with a constant acceleration of 4 m/s^2. How long does the drag racer take to travel 50 m?

A. 2 s
B. 5 s
C. 10 s
D. 12.5 s
E. 25 s

Question 3: Renee skis down a slope with a velocity $v_x = 10$ m/s, and no initial velocity in the y-direction ($v_{y0} = 0$). While keeping a constant v_x, she turns by maintaining a constant acceleration a_y in the y-direction. If she wants to hit a flag on a slalom course +10 meters away in the x-direction and +10 meters in the y-direction, how big does her acceleration a_y have to be?

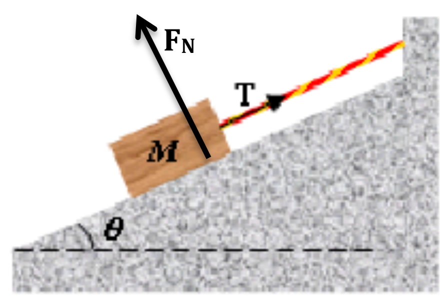


A. $a_y = 1\ m/s^2$
B. $a_y = 5\ m/s^2$
C. $a_y = 10\ m/s^2$
D. $a_y = 20\ m/s^2$
E. $a_y = 50\ m/s^2$

Question 4: My 1 kg laptop is sitting on my tray table, on an airplane flying west. The coefficient of static friction between the laptop and table is $\mu_S = 0.2$. What is the maximum acceleration the airplane can undergo before my laptop starts to slide? Assume $g = 10\ m/s^2$.

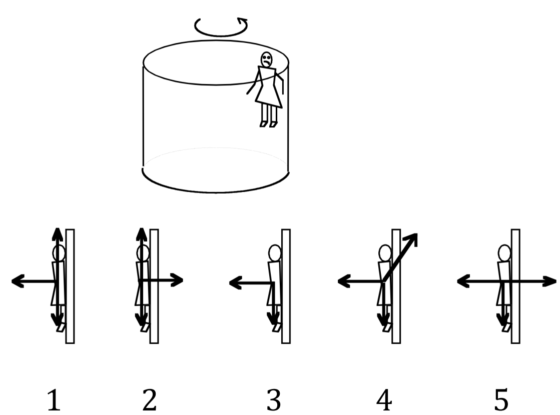
A. $a_{max} = 1\ m/s^2$
B. $a_{max} = 2\ m/s^2$
C. $a_{max} = 5\ m/s^2$
D. $a_{max} = 10\ m/s^2$
E. $a_{max} = 20\ m/s^2$

Question 5: A block with mass M is held motionless on a ramp inclined at an angle θ from horizontal by a string that exerts a tension T (tangential to the plane of the ramp). The surface of the ramp exerts a normal force F_N upon the mass. What is the magnitude of F_N?



A. $Mg \sin\theta$
B. $Mg \cos\theta$
C. Mg
D. $Mg \tan\theta$
E. $T \cos\theta$

Question 6: Alyssa is riding in a "barrel of fun" ride at a carnival. The ride is spinning fast enough that she remains at a constant height on the wall. Which of the numbered free body diagrams correctly shows the forces acting upon her (with the wall on her right side in each case)?



A. 1
B. 2
C. 3
D. 4
E. 5

Question 7: Dylan lifts a book with mass m a vertical distance h. At the beginning and end of the lift, the book is at rest. What is the work W_D done by Dylan on the book, the work W_G done by the force of gravity on the book W_G, and the total work W_{net} done by all forces on the book?

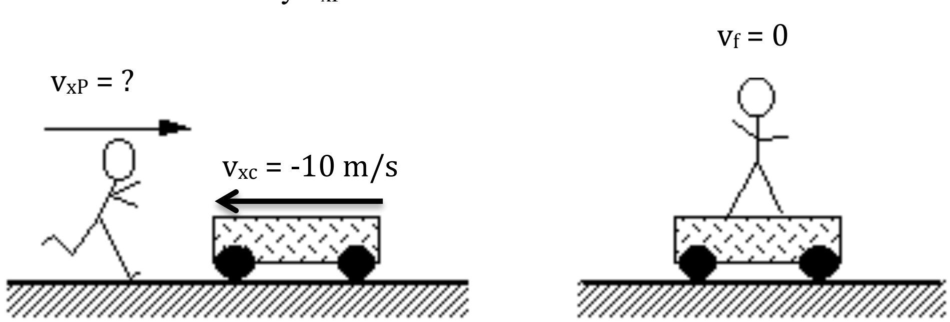
A. $W_D = mgh$, $W_G = -mgh$, $W_{net} = 0$
B. $W_D = -mgh$, $W_G = mgh$, $W_{net} = 0$
C. $W_D = mgh$, $W_G = 0$, $W_{net} = mgh$
D. $W_D = 0$, $W_G = -mgh$, $W_{net} = -mgh$
E. $W_D = 0$, $W_G = 0$, $W_{net} = mgh$

Question 8: Riley launches a 200 g (0.2 kg) puck along a shuffleboard table with an initial velocity v_o. The friction between the puck and the table exerts a total force of 10 N on the puck as it slows down. If Riley wants her puck to come to a stop perfectly at the end of the 4 m table, what should the puck's initial velocity be?

A. $v_o = 1$ m/s
B. $v_o = 2$ m/s
C. $v_o = 4$ m/s
D. $v_o = 10$ m/s
E. $v_o = 20$ m/s

Question 9: Parker is standing in a parking lot when he sees a runaway shopping cart heading straight at him. After doing some quick calculations, he decides to run towards the cart and jump onto it with exactly the right velocity so that the cart (with him on it) comes to a stop. If Parker's mass is 50 kg, the cart's mass is 10 kg, and the cart is traveling toward Parker with a velocity of $v_{xc} = -10$ m/s, what should Parker's velocity v_{xP} toward the cart be?

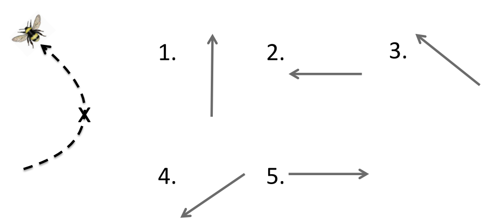
A. 1 m/s
B. 2 m/s
C. 5 m/s
D. 10 m/s
E. 20 m/s



Question 10: A very heavy (>10 kg) bowling ball moving at 10 m/s undergoes a head-on elastic collision with a very small (<1 g) marble that starts at rest. After the collision the bowling ball maintains almost exactly the same 10 m/s velocity. What is the approximate final velocity of the marble?

A. 0 m/s
B. 5 m/s
C. 10 m/s
D. 20 m/s
E. 40 m/s

Question 11: The dashed line indicates the curved path taken by a bumblebee. If the speed of the bee increases continuously throughout the interval shown, which numbered arrow shows the direction of the net acceleration of the bee as it passes the point labeled 'X'?

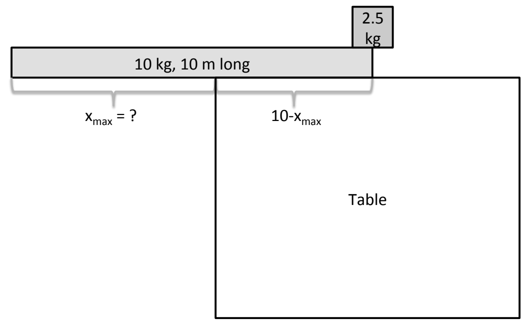


A. 1
B. 2
C. 3
D. 4
E. 5

Question 12: Shelby is riding on a merry-go-round. The merry-go-round (with her on it) has a moment of inertia $I = 100$ kg m^2, and is rotating with an initial angular velocity $\omega_0 = 10$ rad/s. To slow down, Shelby drags her foot on the ground, exerting a constant torque $\tau = 50$ N m. What total angular displacement does the merry-go-round rotate through before it comes to a stop?

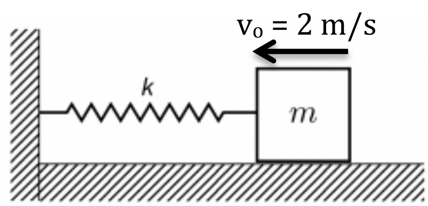
A. 10 radians
B. 25 radians
C. 50 radians
D. 100 radians
E. 500 radians

Question 13: A 10 kg board that is 10 m long is placed on a table with one end hanging off the edge. A 2.5 kg mass is placed on the end that is on the table. How much of the board can hang off the edge of the table before the board tips and falls off?



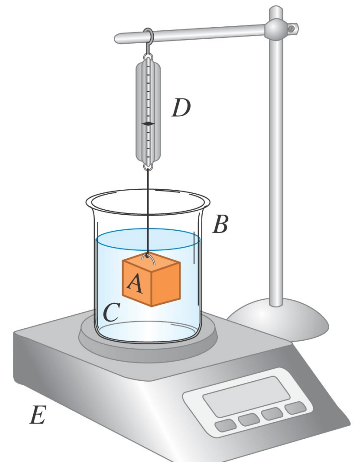
A. $x_{max} = 4$ m
B. $x_{max} = 5$ m
C. $x_{max} = 6$ m
D. $x_{max} = 7$ m
E. $x_{max} = 8$ m

Question 14: A mass m = 4 kg on a spring with spring constant k = 16 N/m is given an initial velocity $v_o = 2$ m/s. What is the amplitude A of the resulting harmonic oscillation of the mass+spring system?



A. A = 1 m
B. A = 2 m
C. A = 4 m
D. A = 8 m
E. A = 16 m

Question 15: Block A has a mass of 2 kg, and a mass density twice that of water. Before the block is in the water, scale D reads 20 N (the block's weight, assuming g = 10 m/s^2), and scale E reads 200 N (the weight of the beaker + water). Block A is then immersed in the water, not touching the bottom of the beaker. What happens to the weight reading on scale E?



A. Stays the same
B. Increases by 10 N
C. Increases by 20 N
D. Decreases by 10 N
E. Decreases by 20 N

Question 16: Water flows through a garden hose with a cross-sectional area of 4 cm^2 at a flow velocity of 2 m/s. I place my thumb over the end of the hose, leaving only 1 cm^2 of area for the water to flow out the end. What velocity does the water spray out of the hose with?

A. $v_{out} = 1$ m/s
B. $v_{out} = 2$ m/s
C. $v_{out} = 4$ m/s
D. $v_{out} = 8$ m/s
E. $v_{out} = 16$ m/s

Question 17: Indiana Jones is being chased by cannibals. To escape, he wants to cross a deep canyon in the jungle using his ladder as a bridge. Indy's ladder is 10 m long, but he finds that it is still 1 mm (0.001 m) too short to bridge the gap. If he could heat up the ladder over a fire, how much would he have to raise its temperature before it would bridge the gap? Assume the coefficient of thermal expansion of the ladder is $\alpha = 1\text{x}10^{-5}/°C$ (0.00001/°C).

A. $\Delta T = 0.1°C$
B. $\Delta T = 1°C$
C. $\Delta T = 10°C$
D. $\Delta T = 100°C$
E. $\Delta T = 1000°C$

Question 18: A hot 1 kg bar of metal is placed into 1 kg of cold water. The specific heat capacities of metal and water are c_{metal} = 500 J/(kg °C) and c_{water} =4200 J/(kg °C). After the metal and water reach equilibrium, how does the final temperature of the metal + water compare to the initial temperatures of the metal and the water?

A. Between them, but closer to the initial temperature of the water
B. Between them, but closer to the initial temperature of the metal
C. Halfway between the initial temperature of the water and the metal
D. The same as the initial temperature of the water
E. The same as the initial temperature of the metal

Question 19: A fixed amount of an ideal monatomic gas is held in a sealed container with volume V_0. The gas is then compressed to a volume $V_0/2$, with no loss of gas, while maintaining the same temperature. What is true about the atoms in the gas after it is compressed to the smaller volume?

A. Their average energy increases
B. Their average energy decreases
C. The frequency of their collisions with the walls of the container increases
D. The frequency of their collisions with the walls of the container decreases

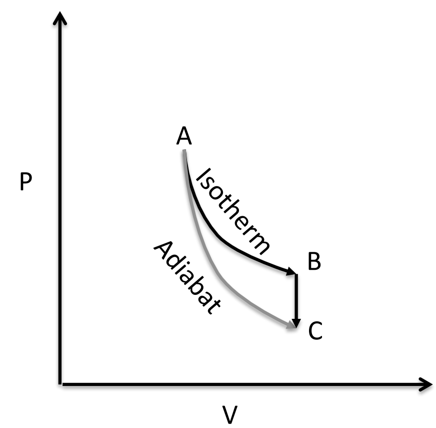
Question 20: An elephant dives off a cliff into a deep lake. Before diving, it inhales a volume $V_0 = 0.2\ m^3$ of air (at atmospheric pressure) into its lungs. Assuming that it does not exhale any air, the pressure in its lungs equilibrates with the pressure of the water around it, and the water has uniform temperature with depth, what is the volume of the air in the elephant's lungs at a depth of 40 m below the surface? Assume atmospheric pressure $P_{atm} = 10^5$ Pa, $g = 10\ m/s^2$, and the mass density of the water $\rho_{water} = 1000\ kg/m^3$.

A. $V_f = 0.01\ m^3$
B. $V_f = 0.02\ m^3$
C. $V_f = 0.04\ m^3$
D. $V_f = 0.1\ m^3$
E. $V_f = 0.2\ m^3$

Question 21: A polar bear hunts for fish at a hole in the ice. While fishing, the polar bear loses 13,000 J of heat to the environment. The bear catches one fish and eats enough to gain 38,000 J of internal energy from caloric energy. This food intake is just enough for the bear to break even and maintain the same overall total internal energy it had before it started fishing. How much work was done by the bear while it was fishing?

A. 25,000 J
B. -25,000 J
C. 51,000 J
D. -51,000 J
E. 38,000 J

Question 22: An ideal monatomic gas is taken from point A to point C along two different paths. Along the top path it is taken along an isotherm from A to B, and then at constant volume from B to C. Along the isotherm AB, the gas gains 20 J of heat. Along the constant volume curve BC, the gas loses 10 J of heat.



If the gas is instead taken directly from point A to point C along the adiabat AC, what is the total change in its internal energy?

A. -30 J
B. -10 J
C. 0 J
D. 10 J
E. 30 J

Question 23: Heat is added to a constant amount of ideal monatomic gas held at a constant pressure $P = P_0$, forcing it to expand from a volume V_0 to a greater volume $V_f = 2V_0$, and thereby doing work. What is the efficiency of this process at converting heat into work ($e = W/Q$)?

A. $e = 1.0$
B. $e = 0.8$
C. $e = 0.6$
D. $e = 0.4$
E. $e = 0.2$

Question 24: Batman is trying to shut off a nuclear reactor that is about to explode, and he only has 4 seconds to do so before it blows. He is still 300 meters away from the command console, but luckily it is voice-actuated, so he can yell 'Off' and shut it down. The reactor is in a room with the air at a temperature of 320 K, and the speed of sound at that temperature is 300 m/s. So, the sound will only take 1 second to get to the console and shut it down. Plenty of time…

But, wait! Mr. Freeze is trying to stop Batman from saving the city, by cooling the air so that the sound of his command can't reach the console in time to avert the explosion. To what temperature must he cool the air in the room before the 'Off' command will be too late and the reactor will blow?

A. 160 K
B. 80 K
C. 40 K
D. 20 K
E. 10 K

Trigonometry (*For right triangle with sides Adjacent, Opposite, and Hypoteneuse)*:

Sin(θ) = O/H   Cos(θ) = A/H   Tan(θ) = O/A $H^2 = O^2 + A^2$ $A_{circle} = \pi r^2$ Circumference=2πr

Sin(30°) = Cos(60°) = ½   Sin(60°) = Cos(30°) =$\sqrt{3}/2$ ~=0.866   Sin(45°) = Cos(45°) = $\sqrt{2}/2$ ~0.707

Sin(0°) = Cos(90°) = 0   Sin(90°) = Cos(0°) = 1

Moment of Inertia

Point mass or thin-walled wheel or hoop: $I = mr^2$ *Solid cylinder or disk:* $I = \frac{1}{2} mr^2$

Thin rod pivoting around end: $I = 1/3\ mr^2$ *Solid sphere:* $I = 2/5\ mr^2$

Kinematics:

$\langle\vec{v}\rangle = \frac{\Delta\vec{r}}{\Delta t}$ $\langle\vec{a}\rangle = \frac{\Delta\vec{v}}{\Delta t}$ $\vec{r} = \vec{r_0} + \vec{v_o}t + \frac{1}{2}\vec{a}t^2$ $v^2 = {v_o}^2 + 2\vec{a}\cdot\Delta\vec{r}$

Newton's Laws:

$\sum\vec{F} = m\vec{a}$ $\overrightarrow{F_{AB}} = -\overrightarrow{F_{BA}}$

Forces:

$F_G = mg$ (@ surface) ${f_s}^{MAX} = \mu_s F_N$ $f_k = \mu_k F_N$

$F_C = ma_c = \frac{mv^2}{r}$ $F_{spring} = -kx$ $F_{Buoyant} = m_{displaced}\ g$

Work & Energy:

$KE_{trans} = \frac{1}{2}mv^2$ $\Delta KE = W_{net}$ $PE_G = mgh$ $PE_{spring} = \frac{1}{2}kx^2$

E = KE + PE $\Delta E = W_{nc}$ $W = \vec{F}\cdot\Delta\vec{r} = |\vec{F}||\Delta\vec{r}|\cos\theta_{Fdr}$

Impulse & Momentum:

$\vec{J} = \vec{F}\Delta t$ $\vec{p} = m\vec{v}$ $\sum\vec{J} = \Delta\vec{p}$ $\sum\vec{p_f} = \sum\vec{p_i}$ *(if F_{ext}=0)*

$\overrightarrow{v_{cm}} = \frac{\sum m_i\vec{v_i}}{\sum m_i} = \sum\vec{p}/M$

Rotational Motion:

$\theta = s/r$ $\langle\omega\rangle = \frac{\langle v_t\rangle}{r} = \frac{\Delta\theta}{\Delta t}$ $\langle\alpha\rangle = \frac{\langle a_t\rangle}{r} = \frac{\Delta\omega}{\Delta t}$ $a_c = v^2/r$

$\theta = \theta_o + \omega_o t + \frac{1}{2}\alpha t^2$ $\omega^2 = {\omega_o}^2 + 2\alpha\Delta\theta$

$\tau = rF\sin\theta_{rF} = F * lever\ arm$ $\sum\tau = I\alpha$ $L = I\omega = mvr\ (point\ mass)$

$W_{rot} = \tau\Delta\theta$ $KE_{rot} = \frac{1}{2}I\omega^2$ $r_{CM} = \frac{\sum m_i r_i}{\sum m_i}$

Harmonic Motion:

$\omega_h = 2\pi f_h = \frac{2\pi}{T} = \sqrt{\frac{k}{m}}$ $x_{max} = A$ $v_{max} = A\omega_h$ $a_{max} = A{\omega_h}^2$

$\omega_{pendulum} = \sqrt{\frac{mgr_{CM}}{I}} = \sqrt{\frac{g}{L}}$ *for simple pendulum of length L*

Fluids:

$\rho = mass/Volume$ $\quad P = F/A$ $\quad P_2 = P_1 + \rho g d$ $\quad F_B = W_{fluid\_displaced}$

$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$ $\quad A_1 v_1 = A_2 v_2$ $(if\ \rho_1 = \rho_2)$

Heat:

$T_c = \frac{5}{9}(T_F - 32)$ $\quad T_K = T_C + 273.15$ $\quad \frac{\Delta L}{L} = \alpha \Delta T$ $\quad \frac{\Delta V}{V} = 3\alpha\Delta T = \beta \Delta T$

$Q_{specific} = mc\Delta T$ $\quad Q_{latent} = mL$ $\quad \frac{Q_{conduction}}{t} = \frac{kA\,\Delta T}{L}$ $\quad \frac{Q_{radiation}}{t} = e\sigma A T^4$

Ideal Gas:

$n = \frac{N}{N_A} = \frac{m}{M_{molar}}$ $\quad PV = nRT = NkT$ $\quad \langle KE \rangle = \frac{3}{2}kT$ $\quad U_{monatomic} = \frac{3}{2}NkT = \frac{3}{2}nRT$

Thermodynamics:

$\Delta U = Q - W$

$W = P\Delta V = nR\Delta T$ *(isobaric, const. P)* $\quad W = nRT\, ln(\frac{V_f}{V_i})$ *(isothermal, const. T)*

$W = -\frac{3}{2}nR(T_f - T_i)$ *(adiabatic, monatomic)* $\quad P_1{V_1}^{\gamma} = P_2{V_2}^{\gamma}$ *(adiabatic)*

$Q = Cn\Delta T$ $\quad C_{P\_monatomic} = \frac{5}{2}R$ $\quad C_{V\_monatomic} = \frac{3}{2}R$ $\quad \gamma = C_P/C_V$ *(= 5/3 for monatomic)*

$e = \frac{|W|}{|Q_H|} = 1 - \frac{|Q_C|}{|Q_H|}$ $\quad |Q_H| = |W| + |Q_C|$ $\quad \frac{|Q_C|}{|Q_H|} = \frac{T_C}{T_H}$ *(Carnot engine)*

$\Delta S = Q/T$ *(Reversible processes)*

Waves

$f = 1/T$ $\quad v = f\lambda$ $\quad v_{string\_wave} = \sqrt{\frac{Tension}{m/L}}$ $\quad v_{sound\_wave} = \sqrt{\frac{\gamma kT}{m}}$