Name

PH105-004 Final Exam

Instructions

1. Answer all questions.
2. Record your responses on a scantron sheet.
3. On your scantron sheet, be sure to bubble in your **full name and CWID**.

1. The coordinate of a particle in meters is given by $x(t) = 16t - 3.0t^3$, where the time t is in seconds. The particle is momentarily at rest at what time?

(a) 0.75 s (b) 3.3 s (c) 1.3 s (d) 2.3 s (e) 0 s

2. A car accelerates from 10.0 m/s to 30.0 m/s at a rate of 3.00 m/s^2. How far does the car travel while accelerating?

(a) 133 m (b) 80.0 m (c) 226 m (d) 399 m (e) 6.67 m

3. Two identical balls, initially at rest, are thrown directly upward, ball A at speed v and ball B at speed $2v$, and they feel no air resistance. Which statement about these balls is correct?

(a) The balls will reach the same height because they have the same mass and the same acceleration.
(b) At their highest point, the acceleration of each ball is instantaneously equal to zero because they stop for an instant.
(c) Ball B will go four times as high as ball A because it had four times the initial kinetic energy.
(d) At its highest point, ball B will have twice as much gravitational potential energy as ball A because it started out moving twice as fast.
(e) Ball B will go twice as high as ball A because it had twice the initial speed.

4. A ball is thrown at a 60.0° angle above the horizontal across level ground. It is thrown from a height of 2.00 m above the ground with a speed of 20.0 m/s and experiences no appreciable air resistance. Take $g = 9.8\,\mathrm{m/s^2}$. The time the ball remains in the air before striking the ground is closest to

(a) 3.64 s. (b) 3.07 s. (c) 3.32 s. (d) 3.53 s. (e) 16.2 s.

5. A 2 kg mass sits on a horizontal frictionless table and is subjected to two horizontal forces, an 8 N force in the x-direction and a 6 N force in the y-direction. What is the magnitude of the acceleration of the mass?

(a) 1 m/s^2 (b) 4 m/s^2 (c) 3.5 m/s^2 (d) 5 m/s^2 (e) 7 m/s^2

6. A 60.0-kg person rides in an elevator while standing on a scale. The scale reads 400 N. The acceleration of the elevator is closest to

(a) zero. (b) 9.80 m/s^2 downward. (c) 6.67 m/s^2 upward. (d) 6.67 m/s^2 downward. (e) 3.13 m/s^2 downward.

7. A spring stretches by 21.0 cm when a 135 N object is attached. What is the weight of a fish that would stretch the spring by 31.0 cm? (a) 91.0 N (b) 279 N (c) 145 N (d) 199 N (e) 305 N

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8. A massless rope passes over a frictionless, massless pulley suspended from the ceiling. A 4 kg block is attached to one end and a 5 kg block is attached to the other end. The magnitude of the acceleration of the 5 kg block is:

(a) g/4 (b) 5g/9 (c) 4g/9 (d) g/5 (e) g/9

9. A baseball player (on Earth) throws a ball of mass 0.30 kg straight up. The average force exerted upward on the ball by the player is 9.0 N and he exerts the force for 0.25 s. What is the speed at which the ball leaves the player's hand? [Ignore air resistance. The ball was at rest when the player started applying his force.]

(a) 7.5 m/s (b) 20 m/s (c) 10 m/s (d) 5.0 m/s (e) 0.63 m/s

10. A 300 g bat flying at 6.00 m/s swallows a 15 g insect that was heading straight toward it with a speed of 3.00 m/s. What is the bat's speed immediately after swallowing the insect?

(a) 5.86 m/s (b) 5.71 m/s (c) 5.14 m/s (d) 5.57 m/s (e) 6.00 m/s

11. Two ice skaters push off against one another starting from a stationary position. The 45.0-kg skater acquires a speed of 0.375 m/s. What speed does the 60.0-kg skater acquire? Assume that any other unbalanced forces during the collision are negligible.

(a) 0.375 m/s (b) 0.500 m/s (c) 0.750 m/s (d) 0.281 m/s (e) 0.000 m/s

12. A 620-g object traveling at 2.1 m/s collides head-on with a 320-g object traveling in the opposite direction at 3.8 m/s. If the collision is perfectly elastic, what is the change in the kinetic energy of the 620-g object?

(a) It gains 0.69 J. (b) It loses 1.4 J. (c) It loses 0.47 J. (d) It loses 0.23 J.
(e) It doesn't lose any kinetic energy because the collision is elastic.

13. A ball of mass 2.3 kg is dropped from a height of 12.9 m. If it is found to reach the ground with a final speed of 11.4 m/s, calculate the work done by the air resistance that it must have experienced on its descent.

(a) 149 J (b) 291 J (c) 0 J (d) 141 J (e) 338 J

14. A tennis ball bounces on the floor three times. If each time it loses 22.0% of its energy due to heating, how high does it rise after the third bounce, provided we released it 2.3 m from the floor?

(a) 11 cm (b) 110 mm (c) 140 cm (d) 110 cm (e) 24 mm

15. A 2.00-kg object traveling east at 20.0 m/s collides with a 3.00-kg object traveling west at 10.0 m/s. After the collision, the 2.00-kg object has a velocity 5.00 m/s to the west. How much kinetic energy was lost during the collision?

(a) 91.7 J (b) 458 J (c) 0.000 J (d) 516 J (e) 175 J

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16. An ice skater with rotational (moment of) inertia I_o is spinning with angular speed ω_o. She pulls her arms in, thereby increasing her angular speed to $4\omega_o$. Her rotational (moment of) inertia is then:

(a) I_o (b) $16I_o$ (c) $I_o/16$ (d) $I_o/4$ (e) $4I_o$

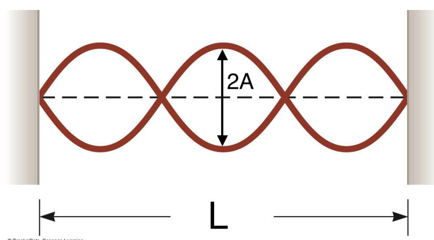
17. A potter's wheel, with rotational inertia 46 kg·m^2, is spinning freely at 40 rpm. The potter drops a lump of clay onto the wheel, where it sticks a distance 1.2 m from the rotational axis. If the subsequent angular speed of the wheel and clay is 32 rpm what is the mass of the clay? The rotational inertia of a disc is $\frac{1}{2}mR^2$, where R is the radius of the disc, while the rotational inertia of a point particle is mR^2, where R is the distance of the particle to the center of rotation.

(a) 5.4 kg (b) 8.0 kg (c) 8.8 kg (d) 7.0 kg (e) 9.2 kg

18. A uniform solid cylinder of radius R and a thin uniform spherical shell of radius R both roll without slipping. If both objects have the same mass and the same kinetic energy, what is the ratio of the linear speed of the cylinder to the linear speed of the spherical shell? A cylinder of radius R and mass M has a rotational inertia of $\frac{1}{2}MR^2$, a spherical shell of the same radius and mass has a rotational inertia $\frac{2}{3}MR^2$.

(a) $\frac{4}{\sqrt{3}}$ (b) $\frac{\sqrt{10}}{2}$ (c) $\frac{\sqrt{3}}{2}$ (d) $\sqrt{\frac{4}{3}}$ (e) $\frac{4}{3}$

19. A standing wave pattern is established in a string as shown, with $L = 6.0\,\text{m}$ and $2A = 0.50\,\text{m}$. The frequency of one of the component traveling waves is measured to be 3.0 Hz. What is the corresponding speed? (Calculate your answer to 2 significant digits.)



(a) 9.00 m/s (b) 1.50 m/s (c) 18.0 m/s (d) 1.33 m/s (e) 12.0 m/s

20. A mass hanging from the end of a spring oscillates up and down with a period of 1.0 s. The mass of the spring in negligible. If the hanging mass is doubled, then the period of oscillation is

(a) 0.5 s (b) 0.7 s (c) 1.0 s (d) 1.4 s (e) 2.0 s

21. A 0.25 kg ideal harmonic oscillator has a total mechanical energy of 4.0 J. If the oscillation amplitude is 20.0 cm, what is the oscillation frequency?

(a) 4.5 Hz (b) 3.2 Hz (c) 1.4 Hz (d) 2.3 Hz (e) 5.7 Hz

22. Waves travel along a 100-m length of string which has a mass of 55 g and is held taut with a tension of 75 N. What is the speed of the waves?

(a) 3.7 m/s (b) 37 m/s (c) 0.37 m/s (d) 370 m/s (e) 3700 m/s

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23. Nitrogen gas that occupies 10 liters at 1 atm and 250°C will occupy what volume at 500 atm and 500°C? Note 1 atm = 101 kPa, (1 liter)(1 kPa) = 1 Joule.

(a) 0.022 liters (b) 0.040 liters (c) 4610 liters (d) 0.12 liters (e) 10 liters

24. A bag of potato chips contains 2.00 L of air when it is sealed at sea level at a pressure of 1.00 atm and a temperature of 20.0°C. What will be the volume of the air in the bag if you take it with you, still sealed, to the mountains where the temperature is 7.00°C and atmospheric pressure is 70.0 kPa? Assume that the bag behaves like a balloon and that the air in the bag is in thermal equilibrium with the outside air. (1 atm = 1.01×10^5 Pa)

(a) 1.01 L (b) 1.38 L (c) 2.76 L (d) 4.13 L (e) 3.84 L

25. An ideal gas has initial volume V and initial pressure P. Suppose the pressure is increased to $2P$, keeping the temperature and amount of gas molecules constant. What is the new volume?

(a) 2V (b) V/2 (c) 4V (d) V/4 (e) V

$$g = 9.81\,\mathrm{m/s^2} \quad G = 6.67\times10^{-11}\,\mathrm{N\,m^2/kg^2}$$
$$N_A = 6.022\times10^{23}\ \text{things/mol}$$
$$k_B = 1.38065\times10^{-23}\ \mathrm{J\cdot K^{-1}}$$
$$R = 8.314\ \text{J/K-mol} = 8.314\ \text{L-kPa/K-mol}$$
$$\text{sphere} \quad V = \frac{4}{3}\pi r^3 \quad A = 4\pi r^2$$
$$ax^2 + bx^2 + c = 0 \Longrightarrow x = \frac{-b\pm\sqrt{b^2-4ac}}{2a}$$
$$\sin\alpha \pm \sin\beta = 2\sin\frac{1}{2}(\alpha\pm\beta)\cos\frac{1}{2}(\alpha\mp\beta)$$
$$\cos\alpha \pm \cos\beta = 2\cos\frac{1}{2}(\alpha+\beta)\cos\frac{1}{2}(\alpha-\beta)$$
$$c^2 = a^2 + b^2 - 2ab\cos\theta_{ab}$$
$$\frac{d}{dx}\sin ax = a\cos ax \qquad \frac{d}{dx}\cos ax = -a\sin ax$$
$$\int\cos ax\,\mathrm{dx} = \frac{1}{a}\sin ax \qquad \int\sin ax\,\mathrm{dx} = -\frac{1}{a}\cos ax$$
$$\sin\theta\approx\theta \qquad \cos\theta\approx 1-\frac{1}{2}\theta^2 \qquad \text{small }\theta$$

$$\Delta\vec{\mathbf{r}} = \vec{\mathbf{r}}_f - \vec{\mathbf{r}}_i$$
$$d \equiv |x_1 - x_2|$$
$$b \equiv |\vec{\mathbf{b}}| = |b_x| \quad \text{one dimension}$$
$$\vec{\mathbf{r}} = x\,\hat{\boldsymbol{\imath}} \quad \text{one dimension}$$
$$\vec{\mathbf{b}} = b_x\,\hat{\boldsymbol{\imath}} \quad \text{one dimension}$$
$$\text{speed} = v = |\vec{\mathbf{v}}|$$
$$\vec{\mathbf{v}} = \lim_{\Delta t\to0}\frac{\Delta\vec{\mathbf{r}}}{\Delta t} \equiv \frac{d\vec{\mathbf{r}}}{dt}$$

$$a_x = \lim_{\Delta t\to0}\frac{\Delta v_x}{\Delta t} \equiv \frac{dv_x}{dt} = \frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d^2x}{dt^2}$$
$$\Delta v_x = \int_{t_i}^{t_f} a_x(t)\,dt \qquad \Delta x = \int_{t_i}^{t_f} v_x(t)\,dt$$
$$x(t) = x_i + v_{x,i}t + \frac{1}{2}a_x t^2$$
$$v_x(t) = v_{x,i} + a_x t$$
$$v_{x,f}^2 = v_{x,i}^2 + 2a_x\Delta x$$
$$a_{x,\text{ramp}} = g\sin\theta$$

$$\Delta U^G = mg\Delta x$$
$$\frac{a_{1x}}{a_{2x}} = -\frac{m_2}{m_1}$$
$$E_{\text{mech}} = K + U \quad K = \frac{1}{2}mv^2$$
$$\Delta E = \Delta K + \Delta U = 0 \quad \text{non-dissipative, closed}$$

$$\Delta\vec{\mathbf{p}} = \vec{\mathbf{0}} \quad \text{isolated system}$$
$$\vec{\mathbf{p}}_f = \vec{\mathbf{p}}_i \quad \text{isolated system}$$
$$\vec{\mathbf{p}} \equiv m\vec{\mathbf{v}}$$
$$m_u = -\frac{\Delta v_{s,x}}{\Delta v_{u,x}}m_s$$
$$\vec{\mathbf{J}} = \Delta\vec{\mathbf{p}}$$
$$v_{1f} = \left(\frac{m_1-m_2}{m_1+m_2}\right)v_{i1} + \left(\frac{2m_2}{m_1+m_2}\right)v_{2i} \quad \text{1D elastic}$$
$$v_{2f} = \left(\frac{2m_1}{m_1+m_2}\right)v_{1i} + \left(\frac{m_2-m_1}{m_1+m_2}\right)v_{2i} \quad \text{1D elastic}$$
$$\Delta E = 0 \quad \text{isolated system}$$
$$K = \frac{1}{2}mv^2$$
$$\vec{v}_{12} = \vec{\mathbf{v}}_2 - \vec{\mathbf{v}}_1 \quad \text{relative velocity}$$
$$v_{12} = |\vec{\mathbf{v}}_2 - \vec{\mathbf{v}}_1| \quad \text{relative speed}$$

$$\vec{\mathbf{a}} = \frac{\sum\vec{\mathbf{F}}}{m} \qquad \vec{\mathbf{a_{cm}}} = \frac{\sum\vec{\mathbf{F}}_{\text{ext}}}{m} \qquad \sum\vec{\mathbf{F}} \equiv \frac{d\vec{\mathbf{p}}}{dt}$$
$$\vec{\mathbf{J}} = \left(\sum\vec{\mathbf{F}}\right)\Delta t = \Delta\vec{\mathbf{p}} \quad \text{constant force}$$
$$\vec{\mathbf{J}} = \int_{t_i}^{t_f}\sum\vec{\mathbf{F}}(t)\,dt = \Delta\vec{\mathbf{p}} \quad \text{time-varying force}$$
$$\vec{\mathbf{F}}_{12} = -\vec{\mathbf{F}}_{21} \qquad F_{\text{grav}} = -mg \qquad F_{\text{spring}} = -k\Delta x$$

$$\Delta E = W$$
$$\Delta U_{\text{spring}} = \frac{1}{2}k\,(x-x_o)^2$$
$$P = \frac{dE}{dt}$$
$$P = F_{\text{ext,x}}\,v_x \quad \text{one dimension}$$

Rotation: we use radians

$$s = \theta r \quad \leftarrow \text{arclength}$$
$$\omega = \frac{d\theta}{dt} = \frac{v_t}{r} \qquad \alpha = \frac{d\omega}{dt}$$
$$a_t = \alpha r \quad \text{tangential} \qquad a_r = -\frac{v^2}{r} = -\omega^2 r \quad \text{radial}$$
$$v_t = r\omega \qquad v_r = 0$$

$$\left(F_{12}^{s}\right)_{\max} = \mu_s F_{12}^{n}$$
$$F_{12}^{k} = \mu_k F_{12}^{n}$$
$$\vec{\mathbf{A}} = \vec{\mathbf{A}}_x + \vec{\mathbf{A}}_y = A_x\,\hat{\boldsymbol{\imath}} + A_y\,\hat{\boldsymbol{\jmath}}$$
$$\vec{\mathbf{A}}\cdot\vec{\mathbf{B}} = AB\cos\phi = A_xB_x + A_yB_y$$
$$W = \vec{\mathbf{F}}\cdot\Delta\vec{\mathbf{r}}_F \quad \text{const non-diss force}$$
$$W = \int_{\vec{\mathbf{r}}_i}^{\vec{\mathbf{r}}_f} \vec{\mathbf{F}}(\vec{\mathbf{r}})\cdot d\vec{\mathbf{r}} \quad \text{variable nondiss force}$$
$\downarrow$ launched from origin, level ground
$$y(x) = (\tan\theta_o)\,x - \frac{gx^2}{2v_o^2\cos^2\theta_o}$$
$$\text{max height } = H = \frac{v_i^2\sin^2\theta_i}{2g}$$
$$\text{Range } = R = \frac{v_i^2\sin 2\theta_i}{g}$$

fluids:

$$P = F/A$$
$$P(d) = P_{\text{surface}} + \rho g d$$
$$\rho = M/V$$
$$\frac{F_1}{A_1} = \frac{F_2}{A_2} \quad F_1x_1 = F_2x_2 \qquad \text{hydraulics}$$
$$B = \text{buoyant force} = \text{weight of water displaced} = \rho_f V_{\text{displ}} g$$
$$P = P_{\text{gauge}} + P_{\text{atm}}$$

thermal stuff:

$$PV = Nk_BT = nRT$$
$$T(K) = T(^\circ C) + 273.15^\circ$$
$$Q = mc\Delta T \quad c = \text{specific heat} \qquad \text{no phase chg}$$
$$Q = \pm mL \qquad \text{phase chg}$$

$$I = \sum_i m_i r_i^2 \Rightarrow \int r^2\,dm = kmr^2 \qquad I = mr^2 \quad \text{point particle}$$
$$I_z = I_{com} + md^2 \quad \text{axis } z \text{ parallel, dist } d$$
$$\vec{\mathbf{L}} = \vec{\mathbf{r}}\times\vec{\mathbf{p}} = I\vec{\boldsymbol{\omega}}$$
$$K = \frac{1}{2}I\omega^2 = L^2/2I$$
$$\Delta K = \frac{1}{2}I\omega_f^2 - \frac{1}{2}I\omega_i^2 = W = \int \tau\,d\theta$$
$$P = \frac{dW}{dt} = \tau\omega$$
$$\tau = rF\sin\theta_{rF} = r_\perp F = rF_\perp$$
$$\tau_{net} = \sum\vec{\boldsymbol{\tau}} = I\vec{\boldsymbol{\alpha}} = \frac{d\vec{\mathbf{L}}}{dt}$$
$$K_{\text{tot}} = K_{cm} + K_{rot} = \frac{1}{2}mv_{cm}^2 + \frac{1}{2}I\omega^2$$

Oscillations:

$$T = \frac{1}{f} = \frac{2\pi}{\omega} \quad \omega = \frac{2\pi}{T} = 2\pi f$$
$$x(t) = A\sin(\omega t + \varphi_i)$$
$$v(t) = \frac{dx}{dt} = \omega A\cos(\omega t + \varphi_i)$$
$$a(t) = \frac{d^2x}{dt^2} = -\omega^2 A\sin(\omega t + \varphi_i)$$
$$\varphi(t) = \omega t + \varphi_i$$
$$a = -\omega^2 x \qquad \frac{d^2x}{dt^2} = -\omega^2 x \qquad \frac{d^2\theta}{dt^2} = -\omega^2\theta$$
$$E = \frac{1}{2}m\omega^2A^2$$
$$\omega = \sqrt{k/m} \quad \text{spring.}$$
$$T = \begin{cases} 2\pi\sqrt{L/g} & \text{simple pendulum} \\ 2\pi\sqrt{I/mgl_{cm}} & \text{physical pendulum}\end{cases}$$

Waves:

$$y = f(x - ct) \quad \text{along +x} \qquad y = f(x + ct) \quad \text{along -x}$$
$$k = \frac{2\pi}{\lambda} \quad \lambda = cT \quad \omega = \frac{2\pi}{T} \quad c = \lambda f$$
$$y(x,t) = f(x,t) = A\sin(kx - \omega t + \varphi_i)$$
$$y(x,t) = 2A\sin kx\cos\omega t \quad \text{standing wave}$$
$$\text{nodes at } x = 0, \pm\frac{\lambda}{2}, \pm\lambda, \pm\frac{3\lambda}{2}$$
$$v = \sqrt{T/\mu} \quad \mu = M_{\text{string}}/L_{\text{string}} \quad T = \text{tension} \qquad \text{strings}$$
$$P_{\text{av}} = \frac{1}{2}\mu\lambda A^2\omega^2/T = \frac{1}{2}\mu A^2\omega^2 c$$
$$\frac{\partial^2 f}{\partial x^2} = \frac{1}{c^2}\frac{\partial^2 f}{\partial t^2}$$
$$f_n = \frac{nv}{\lambda} = \frac{nv}{2L} \quad \lambda_n = \frac{2L}{n} \quad n = 1,2,3\ldots \qquad \text{strings \& open-open pipe}$$
$$f_n = \frac{nv}{\lambda} = \frac{nv}{4L} \quad \lambda_n = \frac{4L}{n} \quad n = 1,3,5\ldots \qquad \text{closed-open pipe}$$

Isolated systems: $\vec{\mathbf{p}}$, $E = K + PE$, L are all conserved.
Static equilibrium: $\sum F = 0$ and $\sum\tau = 0$ about any axis.
Elastic collision: KE and p are both conserved.
Inelastic collision: only p is conserved, not KE.

Derived unit	Symbol	equivalent to
newton	N	$\text{kg}\cdot\text{m/s}^2$
joule	J	$\text{kg}\cdot\text{m}^2/\text{s}^2 = \text{N}\cdot\text{m}$
watt	W	$\text{J/s} = \text{m}^2\cdot\text{kg/s}^3$

Power	Prefix	Abbreviation
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	µ
10^{-3}	milli	m
10^{-2}	centi	c
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T