Name (print): ________________________________
(First)  (Last)

WSU ID Number (9 digit): ________________________________

Please circle your quiz section:

Monday  11:45 AM (K. Dhindsa)
Tuesday 10:40 AM  (J. Huang)
Wednesday 11:45 AM (K. Dhindsa)
Thursday 10:40 AM (J. Huang)

Instructions:

1) Print your name and ID number at the top. Indicate on the scantron sheet which exam you have (A or B) by marking either “A” or “B” in a blank area near the top center of the scantron sheet.

2) Keep the cover of exam CLOSED until the exam has started!

3) Using a pencil, fill out the answer sheet boxes and bubbles with your name and identification number (include leading 0’s in ID number) before starting the exam (you do not need to include date of birth, grade, sex, etc.).

4) You will have 50 minutes to do the exam.

5) The scantron sheet will not be returned. You will get back the exam itself from your quiz instructor. An exam key will be posted on Blackboard/lecture website.

6) You may use a non-graphing calculator. No other electronic devices may be used. Cellphones, PDAs, etc., cannot be used as a calculator.

7) When you are finished with the exam, please bring your student ID, the answer sheet and the exam to the instructor.

8) You are NOT to use notes or books during the exam, or to communicate with another student, or to look at another student’s exam. Any violation can result in a grade of “zero” for this exam or a failing grade for this course.

All questions carry the same weight.
1. A mechanic turns a wrench using a force of 24 N at a distance of 17 cm from the rotation axis. The force is perpendicular to the wrench handle. What magnitude torque does she apply to the wrench?

A. 118 N·m  
B. 4.08 N·m  
C. 1.18 N·m  
D. 0.63 N·m  
E. 408 N·m

2. Four point masses of 1.4 kg each are arranged in a square on massless rods. The length of a side of the square is \(d = 0.56\) m. What is the rotational inertia for rotation about an axis passing through masses B and C?

A. 0.439 kg·m\(^2\)  
B. -0.878 kg·m\(^2\)  
C. 0 kg·m\(^2\)  
D. -0.439 kg·m\(^2\)  
E. 0.878 kg·m\(^2\)

3. A skater is initially spinning at a rate of 17.7 rad/s with a rotational inertia of 2.93 kg·m\(^2\) when her arms are extended. What is her angular velocity after she pulls her arms in and reduces her rotational inertia to 1.65 kg·m\(^2\)?

A. 17.7 rad/s  
B. 21.3 rad/s  
C. 31.4 rad/s  
D. 0 rad/s  
E. 3.1 rad/s

4. A container is filled with gas at a pressure of \(4.3 \times 10^5\) Pa. The container is a cube, 0.10 m on a side, with one side facing south. What is the magnitude of the force on the south side of the container due to the gas inside?

A. 43 kN  
B. 43 N  
C. 430 N  
D. 4.3 kN  
E. 4.3 N
5. A hydraulic lift is lifting a car that weighs 14 kN. The area of the piston supporting the car is \( A_2 \), the area of the other piston is \( A_1 \), and the ratio \( A_2/A_1 \) is 108.5. How far must the small piston be pushed down to raise the car a distance of 2.0 cm? [Hint: Consider the work to be done.]

A. 14 m  
B. 14 cm  
C. 2.17 m  
D. 2.17 cm  
E. Impossible to determine

6. Imagine holding two identical bricks under water. Brick \( A \) is just beneath the surface of the water, while brick \( B \) is at a greater depth. Which of the following statements is correct?

A. The force needed to hold brick \( B \) in place is larger than the force required to hold brick \( A \) in place.  
B. The force needed to hold brick \( B \) in place is the same as the force required to hold brick \( A \) in place.  
C. The force needed to hold brick \( B \) in place is smaller than the force required to hold brick \( A \) in place.  
D. There is not enough information to assess the relationship between the force needed to hold brick \( B \) and the force required to hold brick \( A \) in place.  
E. None of the above.

7. A clock has a pendulum that performs one full swing every 5.0 sec. What is the length of the pendulum?

A. 6.2 m  
B. 5.0 m  
C. 12 m  
D. 1.5 m  
E. Impossible to determine

8. A mass on the spring in simple harmonic oscillator has amplitude \( A \) and period \( T \). If the mass is quadrupled (increased by a factor of four), what will happen to the period?

A. The period will decrease by a factor of four  
B. The period will decrease by a factor of two  
C. The period will increase by a factor of two  
D. The period will increase by a factor of four  
E. The period will not change
9. A 1.0 kg mass is connected to a spring with a spring constant of 9.00 N/m. If the initial velocity is 0.0 cm/s and the initial displacement is 2.0 cm, then what is the maximum kinetic energy of the simple harmonic motion?

A. 0.0090 J  
B. 0.0075 J  
C. 0.0018 J  
D. 0.0012 J  
E. 0.014 J

10. A fisherman notices a buoy bobbing up and down in the water in ripples produced by waves from a passing speedboat. These waves travel at 3.3 m/s and have a wavelength of 7.8 m. At what frequency does the buoy bob up and down?

A. 12.2 Hz  
B. 4.23 Hz  
C. 3.3 Hz  
D. 0.423 Hz  
E. 100 Hz

11. By shaking one end of a stretched string, a single pulse is generated. The traveling pulse carries

A. mass  
B. energy  
C. momentum  
D. energy and momentum  
E. mass, energy and momentum

12. An ambulance traveling at 44 m/s approaches a car heading in the opposite direction at a speed of 28 m/s. The ambulance driver has a siren sounding at 550 Hz. At what frequency does the driver of the car hear the siren? You can take the speed of sound in the air as equal to 343 m/s.

A. 527 Hz  
B. 682 Hz  
C. 448 Hz  
D. 100 Hz  
E. 580 Hz
13. A guitar’s E-string has a length 65 cm and a mass 0.29 g. It vibrates with a fundamental frequency of 329.63 Hz. Determine the tension with which the string is stretched. [Hint: Consider the speed of the wave.]

A. 65 N  
B. 82 N  
C. 122 N  
D. 32 N  
E. Impossible to determine

14. The intensity of the sound wave from an airplane is $1.0 \times 10^2$ W/m$^2$ at 5.0 m. What is the intensity at 100 m?

A. 0.53 W/m$^2$  
B. 5.0 W/m$^2$  
C. 0.25 mW/m$^2$  
D. 0.25 W/m$^2$  
E. Impossible to determine

15. Consider an organ pipe, which is closed at one end and open at the other. If you increase the length of the pipe, the fundamental frequency of the standing sound wave will

A. increase  
B. decrease  
C. not change  
D. disappear  
E. impossible to determine
Possibly useful equations:

**Physical Constants**
- \( g = 9.80 \, \text{m/s}^2 \) (always down!)
- \( G = 6.67 \times 10^{-11} \, \text{m}^3/\text{kg} \cdot \text{s}^2 \)
- \( P_{\text{atm}} = 101.3 \, \text{kPa} \)
- \( \rho_{\text{water}} = 1000 \, \text{kg/m}^3 \)
- \( 0^\circ \text{C} = 273.15 \, \text{K} \)

**Chapter 1**
- Surface area of a sphere: \( S = 4\pi r^2 \) (\( r \) is a radius)
- Surface area of a cube: \( S = 6a^2 \) (\( a \) is a side)
- Volume of a sphere: \( V = \frac{4}{3} \pi r^3 \)
- Volume of a cube: \( V = a^3 \)
- Quadratic equation: \( ax^2 + bx + c = 0 \); solution: \( x_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \)

**Chapter 2**
- Displacement (change in position): \( \Delta \vec{r} = \vec{r}_f - \vec{r}_i \)
- Average velocity: \( \vec{v}_{av} = \frac{\Delta \vec{r}}{\Delta t} \); average acceleration: \( \vec{a}_{av} = \frac{\Delta \vec{v}}{\Delta t} \)
- Constant acceleration equations:
  - \( \Delta v_x = v_{fx} - v_{ix} = a_x \Delta t \)
  - \( \Delta x = x_f - x_i = \frac{1}{2} \left( v_{fx} + v_{ix} \right) \Delta t \)
  - \( \Delta x = v_{ix} \Delta t + \frac{1}{2} a_x \left( \Delta t \right)^2 \)
  - \( v_{fx}^2 - v_{ix}^2 = 2a_x \Delta x \)

**Chapter 3**
- Two-dimensional motion
  - \( \sin = \frac{\text{opposite}}{\text{hypotenuse}} \)
  - \( \cos = \frac{\text{adjacent}}{\text{hypotenuse}} \)
  - \( \tan = \frac{\text{opposite}}{\text{adjacent}} \)

  Right triangle: \( a^2 + b^2 = c^2 \)

**Chapter 4**
- Force and Newton’s Laws of Motion
  - Newton’s 2nd Law: \( \vec{a} = \sum \frac{\vec{F}}{m} \) or \( \sum \vec{F} = m\vec{a} \)
  - The magnitude of the gravitational force: \( F = \frac{G m_1 m_2}{r^2} \)
  - Weight: \( W = mg \)
  - Static friction: \( f_s \leq \mu_s N \)
  - Kinetic friction: \( f_k = \mu_k N \)
Chapter 5
  • Circular Motion
    o Angular displacement: $\Delta \theta = \theta_f - \theta_i$; average angular velocity $\bar{\omega} = \frac{\Delta \bar{\theta}}{\Delta t}$
    o $s = r\theta$, 1 complete circle = 1 revolution = $2\pi$ radians; $f = \frac{1}{T}$, $\omega = 2\pi f$
    o To relate linear to angular quantities: $v = \omega r$
    o Acceleration in uniform circular motion: $a_r = \frac{v^2}{r} = \omega^2 r$
    $\Delta \omega = \omega_f - \omega_i = \alpha \Delta t$
    $\Delta \theta = \frac{1}{2} (\omega_f + \omega_i) \Delta t$
    $\Delta \theta = \omega_i \Delta t + \frac{1}{2} \alpha \Delta t^2$
    o $\omega_f^2 - \omega_i^2 = 2\alpha \Delta \theta$
    o $\sum F_r = m\ddot{a}_r = m\frac{v^2}{r}$

Chapter 6
  • Work and Energy
    o Work: $W = F \Delta r \cos \theta$ (If $F$ and $r$ are along the $x$-axis then $W = F \Delta x$).
    o Translational kinetic energy: $K_{\text{trans}} = \frac{1}{2}mv^2$.
    o The Work-Kinetic Energy Theorem: $W_{\text{total}} = \Delta K$
    o The gravitational potential energy close to earth: $U_{\text{grav}} = mg \gamma$
    o Gravitational potential energy everywhere: $U_{\text{grav}} = -GM_1M_2/r$
    o The potential energy associated with a spring: $U_{\text{spring}} = \frac{1}{2}kx^2$.
    o The force required to pull on a spring: $F_{\text{spring}} = -kx$
    o Conservation of energy: $E_{\text{initial}} = E_{\text{final}}$
    o Power: $P = \frac{\Delta E}{\Delta t} = Fv \cos \theta$

Chapter 7
  • Momentum, Impulse and Conservation of Momentum
    o Linear momentum: $\vec{p} = m\vec{v}$ (add as vectors)
    o Conservation of momentum: $\sum \vec{p}_{\text{initial}} = \sum \vec{p}_{\text{final}}$
    o Impulse: $\Delta \vec{p} = \sum \vec{F} \Delta t$
Chapter 8
- Rotations, torques, and angular momentum
  - The rotational kinetic energy: \( K_{\text{rot}} = \frac{1}{2} I \omega^2 \)
  - Rotational inertia: \( I = \sum mr^2 \)
  - Torque: \( \tau = \pm rF_\perp = \pm r_\perp F = rF \sin \theta \)
  - Torque and angular acceleration \( \alpha \): \( \tau = I \alpha \), \( \alpha = \lim_{\Delta t \to 0} \frac{\Delta \omega}{\Delta t} \)
  - Angular momentum: \( L = I \omega \)
  - **Conservation of angular momentum**: if \( \sum \tau = 0, L_i = L_f \)
  - Rotational work: \( W = \tau \cdot \Delta \theta \)

Chapter 9
- \( P = F/A \)
- \( \rho = m/V, \text{S.G.} = \rho/\rho_{\text{water}}, P = P_{\text{atm}} + \rho gd, F_B = \rho \eta g V_{\text{sub}} \)
- \( \Delta V = A_1 v_1 = A_2 v_2, P_{1} + \rho g v_1 + \frac{1}{2} \rho v_1^2 = P_{2} + \rho g v_2 + \frac{1}{2} \rho v_2^2 \)
- Viscous flow (Poiseuille): \( \frac{\Delta V}{\Delta t} = \frac{\pi}{8} \frac{\Delta P/L}{\eta} r^4 \)
- Viscous drag: \( F_D = 6\pi \eta r v \)
- Surface Tension in a bubble: \( \Delta P = 2\gamma/r \)

Chapter 10
- \( \frac{F}{A} = \frac{Y}{L} \frac{\Delta L}{L} \quad \frac{F}{A} = \frac{S}{L} \frac{\Delta x}{L} \quad \Delta P = -B \frac{\Delta V}{V} \)
- Simple Harmonic Motion (SHM)
  - The maximum displacement, velocity and acceleration in SHM:
    \( x_m = A \quad v_m = \omega A \quad a_m = \omega^2 A \)
  - The equations of motion for SHM:
    Assume \( x = A \) at \( t = 0 \): \( x = A \cos \omega t, v_x = -\omega A \sin \omega t, a_x = -\omega^2 A \cos \omega t \)
  - The mechanical energy for SHM: \( E_{\text{mech}} = \frac{1}{2} kA^2 = \frac{1}{2} mv^2 + \frac{1}{2} kx^2 \)
  - The angular frequency (velocity) for a mass-spring system: \( \omega_{\text{spring}} = \sqrt{\frac{k}{m}} \)
  - The angular frequency for a pendulum: \( \omega_{\text{pendulum}} = \sqrt{\frac{g}{L}} \)
Chapter 11

• Waves
  o Wave intensity (for an isotropic source): \( I = \frac{\text{Power}}{\text{Area}} = \frac{P}{4\pi r^2} \)
  o The speed of transverse wave on a string: \( v_{\text{string}} = \sqrt{\frac{F}{\mu}} \); \( k = \frac{2\pi f}{\lambda} = \frac{2\pi f}{v} \)
  o \( f, \omega, \lambda \) are related!
  \[ 2\pi f = \omega; \quad k = \frac{2\pi}{\lambda} \]
  o The speed of a wave: \( v = \frac{\omega}{k} \)
  o The distance between two adjacent nodes is \( \frac{1}{2} \lambda \) (also the distance between two adjacent antinodes)
  o Standing waves on a string: \( \lambda_n = \frac{2L}{n}; \quad f_n = n \frac{v}{2L} \) (n=1,2,3,...)

Chapter 12

• Sound
  o Intensity for an isotropic source (see chapter 11)
  \[ v = \sqrt{\frac{B}{\rho}} \quad v = \sqrt{\frac{Y}{\rho}} \quad v = 331 + 0.606T_c \text{ m/s} \]
  o Pressure amplitude Vs displacement amplitude: \( p_0 = \omega v \rho s_0 \)
  o \( I = \frac{p_0^2}{2\rho v} \)
  o Sound intensity level: \( \beta = (10 \text{ dB}) \log \left( \frac{I}{I_0} \right) \); \( I_0 = 1.00 \times 10^{-12} \text{ W/m}^2 \)
  o Standing sound wave in a pipe open at both ends: see formulas for standing waves on strings in Chapter 11 section
  o Standing sound wave in a pipe closed at one end:
    \[ \lambda_n = \frac{4L}{n}; \quad f_n = n \frac{v}{4L} \] (n=1,3,5,...)
  o Doppler shift: \( f_o = \left( \frac{v - v_o}{v - v_s} \right) f_s \)
    (\( v_o \) and \( v_s \) are positive in the direction of propagation of the wave)

**Conversion factors:**
1 m = 39.37 inches;
1 km = 1000 m = 100,000 cm;
1 mi = 1.609 km;
1 kg = 2.20 lb