Exam 3 version A

Name___________________________________

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) What test version do you have? 1) _______

A) B) C) D)

2) A string is attached to the rear–view mirror of a car. A ball is hanging at the other end of the string. The car is driving around in a circle, at a constant speed. Which of the following lists gives all of the forces directly acting on the ball? 2) _______

A) tension
B) tension and gravity
C) tension, gravity, and the centripetal force
D) tension, gravity, the centripetal force, and friction

3) An object moves in a circle of radius R at constant speed with a period T. If you want to change only the period in order to cut the object's acceleration in half, the new period should be 3) _______

A) $T/\sqrt{2}$. B) $T\sqrt{2}$. C) $4T$. D) $T/4$. E) $T/2$.

4) Consider a uniform solid sphere of radius R and mass M rolling without slipping. Which form of its kinetic energy is larger, translational or rotational? 4) _______

A) Both forms of energy are equal.
B) Its translational kinetic energy is larger than its rotational kinetic energy.
C) Its rotational kinetic energy is larger than its translational kinetic energy.
D) You need to know the speed of the sphere to tell.

5) Two particles, A and B, are in uniform circular motion about a common center. The acceleration of particle A is 8.5 times that of particle B. The period of particle B is 2.0 times the period of particle A. The ratio of the radius of the motion of particle A to that of particle B is closest to 5) _______

A) $r_A/r_B = 2.1$.
B) $r_A/r_B = 17$.
C) $r_A/r_B = 4.3$.
D) $r_A/r_B = 0.24$.
E) $r_A/r_B = 18$.

6) A uniform solid sphere of mass M and radius R rotates with an angular speed ω about an axis through its center. A uniform solid cylinder of mass M, radius R, and length $2R$ rotates through an axis running through the central axis of the cylinder. What must be the angular speed of the cylinder so it will have the same rotational kinetic energy as the sphere? 6) _______

A) $\sqrt{2/5}\,\omega$ B) $2\omega/5$ C) $2\omega/\sqrt{5}$ D) $4\omega/5$ E) $\omega/\sqrt{5}$

7) A machinist turns the power on to a grinding wheel, which is at rest at time $t = 0.00$ s. The wheel accelerates uniformly for 10 s and reaches the operating angular velocity of 25 rad/s. The wheel is run at that angular velocity for 37 s and then power is shut off. The wheel decelerates uniformly at 1.5 rad/s^2 until the wheel stops. In this situation, the time interval of angular deceleration (slowing down) is closest to: 7) _______

A) 15 s B) 21 s C) 17 s D) 19 s E) 23 s

8) A uniform disk, a uniform hoop, and a uniform solid sphere are released at the same time at the top of an inclined ramp. They all roll without slipping. In what order do they reach the bottom of the ramp? 8) _______

A) hoop, disk, sphere
B) disk, hoop, sphere
C) hoop, sphere, disk
D) sphere, disk, hoop
E) sphere, hoop, disk

9) A heavy boy and a lightweight girl are balanced on a massless seesaw. If they both move forward so that they are one–half their original distance from the pivot point, what will happen to the seesaw? Assume that both people are small enough compared to the length of the seesaw to be thought of as point masses. 9) _______

A) It is impossible to say without knowing the distances.
B) The side the girl is sitting on will tilt downward.
C) It is impossible to say without knowing the masses.
D) Nothing will happen; the seesaw will still be balanced.
E) The side the boy is sitting on will tilt downward.

10) A 72.0–kg person pushes on a small doorknob with a force of 5.00 N perpendicular to the surface of the door. The doorknob is located 0.800 m from axis of the frictionless hinges of the door. The door begins to rotate with an angular acceleration of 2.00 rad/s^2. What is the moment of inertia of the door about the hinges? 10) _______

A) 7.52 $kg{\cdot}m^2$
B) 2.00 $kg{\cdot}m^2$
C) 0.684 $kg{\cdot}m^2$
D) 4.28 $kg{\cdot}m^2$
E) 2.74 $kg{\cdot}m^2$

11) A string is wrapped around a pulley with a radius of 2.0 cm and no appreciable friction in its axle. The pulley is initially not turning. A constant force of 50 N is applied to the string, which does not slip, causing the pulley to rotate and the string to unwind. If the string unwinds 1.2 m in 4.9 s, what is the moment of inertia of the pulley? 11) _______

A) 0.17 $kg{\cdot}m^2$
B) 0.017 $kg{\cdot}m^2$
C) 14 $kg{\cdot}m^2$
D) 0.20 $kg{\cdot}m^2$
E) 17 $kg{\cdot}m^2$

12) A thin cylindrical shell is released from rest and rolls without slipping down an inclined ramp that makes an angle of 30° with the horizontal. How long does it take it to travel the first 3.1 m? 12) ______

A) 1.1 s B) 1.4 s C) 2.1 s D) 1.8 s E) 1.6 s

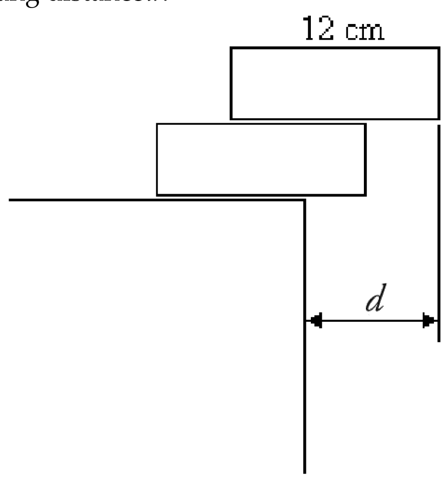
13) A uniform solid cylinder of radius R and a thin uniform spherical shell of radius R both roll without slipping. If both objects have the same mass and the same kinetic energy, what is the ratio of the linear speed of the cylinder to the linear speed of the spherical shell? 13) ______

A) $\sqrt{4/3}$ B) $\sqrt{3}/2$ C) $\sqrt{10}/3$ D) $4/3$ E) $4/\sqrt{3}$

14) A nonuniform, 80.0-g, meterstick balances when the support is placed at the 51.0-cm mark. At what location on the meterstick should a 5.00-g tack be placed so that the stick will balance at the 50.0 cm mark? 14) ______

A) 66.0 cm B) 34.0 cm C) 16.0 cm D) 35.0 cm E) 67.0 cm

15) A child is trying to stack two uniform wooden blocks, 12 cm in length, so they will protrude as much as possible over the edge of a table, without tipping over, as shown in the figure. What is the maximum possible overhang distance d? 15) ______



A) 9 cm B) 7 cm C) 8 cm D) 5 cm E) 6 cm

16) A dump truck has a large cubical concrete block in its bed. The coefficients of friction between this block and the floor of the bed are $\mu_k = 0.450$ and $\mu_s = 0.650$. As the bed is slowly tilted above the horizontal, will the brick first begin to slide or will it first tip over? 16) ______

A) It will first tip over.
B) It is impossible to answer without knowing the dimensions of the block.
C) It will tip over just as it begins to slide.
D) It is impossible to answer without knowing the mass of the block.
E) It will first begin to slide.

17) A uniform solid cylindrical log begins rolling without slipping down a ramp that rises 28.0° above the horizontal. After it has rolled 4.20 m along the ramp, what is the magnitude of the linear acceleration of its center of mass? 17) ______

A) 9.80 m/s^2
B) 2.30 m/s^2
C) 3.07 m/s^2
D) 4.60 m/s^2
E) 3.29 m/s^2

18) A mass M is attached to an ideal massless spring. When this system is set in motion with amplitude A, it has a period T. What is the period if the amplitude of the motion is increased to $2A$? 18) ______

A) T B) $\sqrt{2}T$ C) $T/2$ D) $4T$ E) $2T$

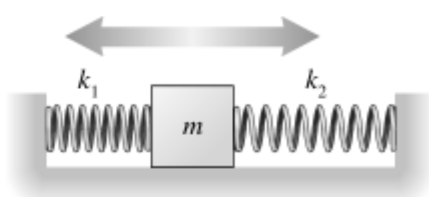
19) A mass M is attached to an ideal massless spring. When this system is set in motion, it has a period T. What is the period if the mass is doubled to $2M$? 19) ______

A) $4T$ B) $2T$ C) $T/2$ D) T E) $\sqrt{2}T$

20) An object that weighs 2.450 N is attached to an ideal massless spring and undergoes simple harmonic oscillations with a period of 0.640 s. What is the spring constant of the spring? 20) ______

A) 24.1 N/m
B) 0.102 N/m
C) 0.610 N/m
D) 2.45 N/m
E) 12.1 N/m

21) A 2.0 kg block on a frictionless table is connected to two ideal massless springs with spring constants k_1 and k_2 whose opposite ends are fixed to walls, as shown in the figure. What is angular frequency of the oscillation if $k_1 = 7.6$ N/m and $k_2 = 5.0$ N/m? 21) ______



A) 3.5 rad/s B) 0.56 rad/s C) 2.5 rad/s D) 0.40 rad/s

22) A 1.6-kg block on a horizontal frictionless surface is attached to an ideal massless spring whose spring constant is 190 N/m. The block is pulled from its equilibrium position at $x = 0.00$ m to a displacement $x = +0.080$ m and is released from rest. The block then executes simple harmonic motion along the horizontal x-axis. What is the velocity of the block at time $t = 0.40$ s? 22) ______

A) -0.30 m/s
B) 0.30 m/s
C) 0.00 m/s
D) -0.82 m/s
E) 0.82 m/s

23) A 2.00-kg object is attached to an ideal massless horizontal spring of spring constant 100.0 N/m and is at rest on a frictionless horizontal table. The spring is aligned along the x-axis and is fixed to a peg in the table. Suddenly this mass is struck by another 2.00-kg object traveling along the x-axis at 3.00 m/s, and the two masses stick together. What are the amplitude and period of the oscillations that result from this collision? 23) ______

A) 0.424 m, 5.00 s
B) 0.424 m, 0.889 s
C) 0.300 m, 1.26 s
D) 0.300 m, 0.889 s
E) 0.424 m, 1.26 s

24) 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? 24) ______

A) 3.2 Hz B) 4.5 Hz C) 2.3 Hz D) 1.4 Hz

25) A certain frictionless simple pendulum having a length L and mass M swings with period T. If both L and M are doubled, what is the new period? 25) ______

A) $2T$ B) $T/4$ C) $\sqrt{2}T$ D) T E) $4T$

26) If we double only the mass of a vibrating ideal mass-and-spring system, the mechanical energy of the system 26) ______

A) increases by a factor of $\sqrt{2}$.
B) increases by a factor of 2.
C) increases by a factor of 3.
D) increases by a factor of 4.
E) does not change.

Formula sheet

$$g = 9.81\,\mathrm{m/s^2}$$

$$\text{sphere} \quad V = \frac{4}{3}\pi r^3 \quad A = 4\pi r^2$$

$$ax^2 + bx^2 + c = 0 \Longrightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$c^2 = a^2 + b^2 - 2ab\cos\theta_{ab}$$

$$\sin\theta \approx \theta \qquad \cos\theta \approx 1 - \frac{1}{2}\theta^2 \qquad \text{small } \theta$$

$$a_x = \lim_{\Delta t \to 0} \frac{\Delta v_x}{\Delta t} \equiv \frac{dv_x}{dt} = \frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d^2x}{dt^2}$$

$$\Delta v_x = \int_{t_i}^{t_f} a_x(t)\,dt \qquad \Delta x = \int_{t_i}^{t_f} v_x(t)\,dt$$

$$x(t) = x_i + v_{x,i}t + \frac{1}{2}a_x t^2$$

$$v_x(t) = v_{x,i} + a_x t$$

$$v_{x,f}^2 = v_{x,i}^2 + 2a_x\Delta x$$

$$a_{x,\text{ramp}} = g\sin\theta$$

$$\Delta U^G = mg\Delta x$$

$$\frac{a_{1x}}{a_{2x}} = -\frac{m_2}{m_1}$$

$$E_{\text{mech}} = K + U \quad K = \frac{1}{2}mv^2$$

$$\Delta E = \Delta K + \Delta U = 0 \quad \text{non-dissipative, closed}$$

$$\Delta E = W$$

$$\Delta U_{\text{spring}} = \frac{1}{2}k\,(x - x_o)^2$$

$$P = \frac{dE}{dt}$$

$$P = F_{\text{ext,x}}\,v_x \quad \text{one dimension}$$

Rotation: we use radians

$$s = \theta r \quad \leftarrow \text{arclength}$$

$$\omega = \frac{d\theta}{dt} = \frac{v_t}{r} \qquad \alpha = \frac{d\omega}{dt}$$

$$a_t = \alpha r \quad \text{tangential}$$

$$a_r = -\frac{v^2}{r} = -\omega^2 r \quad \text{radial}$$

$$v_t = r\omega \qquad v_r = 0$$

$$\Delta\Theta = \omega_i t + \frac{1}{2}\alpha t^2 \quad \text{const } \alpha$$

$$\omega_f = \omega_i + \alpha t \quad \text{const } \alpha$$

$$\Delta x = r\theta \quad v = r\omega \quad a = r\alpha \quad \text{no slipping}$$

$$I = \sum_i m_i r_i^2 \Rightarrow \int r^2\,dm = cmr^2 \qquad I = mr^2 \quad \text{point particle}$$

$$I_z = I_{com} + md^2 \quad \text{axis } z \text{ parallel, dist } d$$

$$\vec{\mathbf{L}} = \vec{\mathbf{r}} \times \vec{\mathbf{p}} = I\vec{\boldsymbol{\omega}} \qquad L = I\omega = mvr$$

$$K = \frac{1}{2}I\omega^2 = L^2/2I$$

$$\Delta K = \frac{1}{2}I\omega_f^2 - \frac{1}{2}I\omega_i^2 = W = \int \tau\,d\theta$$

$$P = \frac{dW}{dt} = \tau\omega$$

$$\tau = rF\sin\theta_{rF} = r_\perp F = rF_\perp$$

$$\tau_{net} = \sum \vec{\boldsymbol{\tau}} = I\vec{\boldsymbol{\alpha}} = \frac{d\vec{\mathbf{L}}}{dt}$$

$$K_{\text{tot}} = K_{cm} + K_{rot} = \frac{1}{2}mv_{cm}^2 + \frac{1}{2}I\omega^2$$

Oscillations:

$$T = \frac{1}{f} = \frac{2\pi}{\omega} \quad \omega = \frac{2\pi}{T} = 2\pi f$$

$$x(t) = A\sin(\omega t + \varphi_i) = A\sin\varphi(t)$$

$$v(t) = \frac{dx}{dt} = \omega A\cos(\omega t + \varphi_i)$$

$$a(t) = \frac{d^2x}{dt^2} = -\omega^2 A\sin(\omega t + \varphi_i) = -\omega^2 x(t)$$

$$\varphi(t) = \omega t + \varphi_i$$

$$a = -\omega^2 x = \frac{d^2x}{dt^2} \qquad \frac{d^2\theta}{dt^2} = -\omega^2\theta$$

$$E = \frac{1}{2}m\omega^2 A^2$$

$$\omega = \sqrt{k/m} \quad \text{spring.}$$

$$T = \begin{cases} 2\pi\sqrt{m/k} & \text{spring} \\ 2\pi\sqrt{L/g} & \text{simple pendulum} \\ 2\pi\sqrt{I/mgl_{cm}} & \text{physical pendulum} \end{cases}$$

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

Moments of inertia of things of mass M

Object	axis	**dimension**	**I**
solid sphere	central axis	radius R	$\frac{2}{5}MR^2$
hollow sphere	central axis	radius R	$\frac{2}{3}MR^2$
solid disc/cylinder	central axis	radius R	$\frac{1}{2}MR^2$
hoop	central axis	radius R	MR^2
point particle	pivot point	distance R to pivot	MR^2
rod	center	length L	$\frac{1}{12}ML^2$
rod	end	length L	$\frac{1}{3}ML^2$
solid regular octahedron	through vertices	side a	$\frac{1}{10}ma^2$