Exam 3

Name________________________________

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

1) Two men, Joel and Jerry, push against a wall. Jerry stops after 10 min, while Joel is able to push for 5.0 min longer. Compare the work they do. 1) _______

A) Both men do positive work, but Jerry does 50% more work than Joel.
B) Both men do positive work, but Joel does 25% more work than Jerry.
C) Both men do positive work, but Joel does 75% more work than Jerry.
D) Both men do positive work, but Joel does 50% more work than Jerry.
E) Neither of them does any work.

2) For general projectile motion, when the projectile is at the highest point of its trajectory 2) _______

A) its velocity is perpendicular to the acceleration.
B) the horizontal component of its velocity is zero.
C) the horizontal and vertical components of its velocity are zero.
D) its velocity and acceleration are both zero.
E) its acceleration is zero.

3) A 4.0–kg object is moving with speed 2.0 m/s. A 1.0–kg object is moving with speed 4.0 m/s. Both objects encounter the same constant braking force, and are brought to rest. Which object travels the greater distance before stopping? 3) _______

A) the 1.0–kg object
B) the 4.0–kg object
C) Both objects travel the same distance.
D) It is impossible to know without knowing how long each force acts.

4) While an object is in projectile motion (with upward being positive) with no air resistance 4) _______

A) the horizontal component of its velocity remains constant and the horizontal component of its acceleration is equal to $-g$.
B) the vertical component of both its velocity and its acceleration remain constant.
C) the horizontal component of its velocity remains constant and the vertical component of its acceleration is equal to $-g$.
D) the vertical component of its velocity remains constant and the vertical component of its acceleration is equal to $-g$.
E) the horizontal component of its velocity remains constant and the vertical component of its acceleration is equal to zero.

5) Two identical balls 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? 5) _______

A) 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.
B) The balls will reach the same height because they have the same mass and the same acceleration.
C) At their highest point, the acceleration of each ball is instantaneously equal to zero because they stop for an instant.
D) Ball B will go four times as high as ball A because it had four times the initial kinetic energy.
E) Ball B will go twice as high as ball A because it had twice the initial speed.

6) A force $F = bx^3$ acts in the x direction, where the value of b is 3.7 N/m^3. How much work is done by this force in moving an object from $x = 0.00$ m to $x = 2.6$ m? 6) _______

A) 13 J B) 57 J C) 42 J D) 50 J

7) A worker lifts a 20.0-kg bucket of concrete from the ground up to the top of a 20.0-m tall building. The bucket is initially at rest, but is traveling at 4.0 m/s when it reaches the top of the building. What is the minimum amount of work that the worker did in lifting the bucket? 7) _______

A) 160 J B) 3.92 kJ C) 4.08 kJ D) 400 J E) 560 J

8) An electron moves with a constant horizontal velocity of 3.0×10^6 m/s and no initial vertical velocity as it enters a deflector inside a TV tube. The electron strikes the screen after traveling 17.0 cm horizontally and 40.0 cm vertically upward with no horizontal acceleration. What is the constant vertical acceleration provided by the deflector? (The effects of gravity can be ignored.) 8) _______

A) 1.4×10^4 m/s^2 B) 8.3×10^2 m/s^2

C) 2.5×10^{14} m/s^2 D) 1.2×10^{14} m/s^2

9) What is the maximum distance we can shoot a dart, from ground level, provided our toy dart gun gives a maximum initial velocity of 2.78 m/s and air resistance is negligible? 9) _______

A) 0.394 m B) 1.58 m C) 1.39 m D) 0.789 m

10) A turbine blade rotates with angular velocity $\omega(t) = 2.00$ rad/s $-$ 2.1 $\text{rad/s}^3\, t^2$. What is the angular acceleration of the blade at $t = 9.10$ s? 10) _______

A) -36.2 rad/s^2

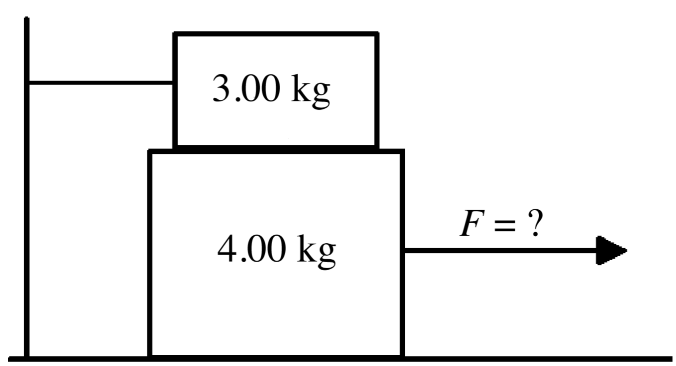
B) -86.0 rad/s^2

C) -38.2 rad/s^2

D) -172 rad/s^2

E) -19.1 rad/s^2

11) A 4.00-kg block rests between the floor and a 3.00-kg block as shown in the figure. The 3.00-kg block is tied to a wall by a horizontal rope. If the coefficient of static friction is 0.800 between each pair of surfaces in contact, what horizontal force F must be applied to the 4.00-kg block to make it move? 11) _______



A) 78.4 N B) 23.5 N C) 54.9 N D) 16.2 N E) 21.1 N

12) 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 12) ______

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

13) A car travels at a steady 40.0 m/s around a horizontal curve of radius 200 m. What is the minimum coefficient of static friction between the road and the car's tires that will allow the car to travel at this speed without sliding? 13) ______

A) 0.952 B) 0.816 C) 0.662 D) 0.736 E) 1.23

14) 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? 14) ______

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

15) A 5.0-m radius playground merry-go-round with a moment of inertia of 2000 kg•m^2 is rotating freely with an angular speed of 1.0 rad/s. Two people, each having a mass of 60 kg, are standing right outside the edge of the merry-go-round and step on it with negligible speed. What is the angular speed of the merry-go-round right after the two people have stepped on? 15) ______

A) 0.40 rad/s
B) 0.80 rad/s
C) 0.67 rad/s
D) 0.20 rad/s
E) 0.60 rad/s

16) In an experiment, a student brings up the rotational speed of a piece of laboratory apparatus to 30.0 rpm. She then allows the apparatus to slow down uniformly on its own, and counts 240 revolutions before the apparatus comes to a stop. The moment of inertia of the apparatus is known to be 0.0850 kg•m^2. What is the magnitude of the retarding torque on the apparatus? 16) ______

A) 0.159 N•m
B) 0.0425 N•m
C) 0.0787 N•m
D) 0.000278 N•m
E) 0.0000136 N•m

17) 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? 17) ______

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

18) A 5.0-m long, 12-kg uniform ladder rests against a smooth vertical wall with the bottom of the ladder 3.0 m from the wall. The coefficient of static friction between the floor and the ladder is 0.28. What distance, measured along the ladder from the bottom, can a 60-kg person climb before the ladder starts to slip? 18) ______

A) 3.3 m B) 3.7 m C) 4.0 m D) 1.7 m E) 1.3 m

19) A solid sphere, solid cylinder, and a hollow pipe all have equal masses and radii and are of uniform density. If the three are released simultaneously at the top of an inclined plane and roll without slipping, which one will reach the bottom first? 19) ______

A) solid sphere
B) solid cylinder
C) hollow pipe
D) They all reach the bottom at the same time.

20) A torque of 12 N • m is applied to a solid, uniform disk of radius 0.50 m, causing the disk to accelerate at 5.7 rad/s^2. What is the mass of the disk? 20) ______

A) 8.5 kg B) 17 kg C) 4.3 kg D) 13 kg

Formula sheet

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

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

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

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

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

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

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

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

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

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

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

$\downarrow$ launched from origin, level ground

$$y(x) = (\tan\theta_o)\,x - \frac{gx^2}{2v_o^2\cos^2\theta_o}$$

$$\text{max height } = H = \frac{v_i^2\sin^2\theta_i}{2g}$$

$$\text{Range } = R = \frac{v_i^2\sin 2\theta_i}{g}$$

$$(F_{12}^2)_{\max} = \mu_s F_{12}^n \qquad F_{12}^k = \mu_k F_{12}^n$$

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

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

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

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

$$\Delta E = W$$

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

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

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

$$W = \left(\sum \vec{\mathbf{F}}\right)\Delta x_F \quad \text{constant force 1D}$$

$$W = \int_{x_i}^{x_f} F_x(x)\,dx \quad \text{nondiss. force, 1D}$$

Rotation: we use radians

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Derived unit	**Symbol**	**equivalent to**
newton	N	kg·m/s^2
joule	J	kg·m^2/s^2 = N·m
watt	W	J/s=m^2·kg/s^3

Power	**Prefix**	**Abbreviation**
10^{-6}	micro	µ
10^{-3}	milli	m
10^{-2}	centi	c
10^{3}	kilo	k
10^{6}	mega	M

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.

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	$\frac{1}{10}ma^2$