Name (print neatly):______________________________Section #:_____

Physics 111 **Exam 3**

First, write your name on this sheet and on the Scantron Card.

The Physics faculty would like to help you do well:

1. Budget your time: 80 minutes/20 questions=4 min each.
2. Questions vary in difficulty. Look for ones you can do first.
3. If you get stuck on a question, move on.
4. All answers are in standard units of m, s, kg and J.
5. If you show your work on the exam sheet you will do better and the work will improve your ability to understand the exam afterward.
6. If any question is unclear, ask a tutor to clarify it immediately.
7. Use a calculator.
8. Answers are approximate; select the closest one.

Since the NJIT Student Council asks for scrupulous fairness in exams, we remind you that you have pledged to comply with the provisions of the NJIT Academic Honor Code. The tutors will help by allowing no devices with internet access.

Signature: ____

1. Glider A of mass 2.5 kg moves with speed 1.7 m/s on a horizontal rail without friction. It collides elastically with glider B of identical mass 2.5 kg, which is initially at rest. After the collision, what is the value of the speed of glider A, in m/s?

a. 1.7
b. 5
c. 1.3
d. 0
e. 0.5

2. A glider of mass 5.0 kg hits the end of a horizontal rail and bounces off with the same speed, in the opposite direction. The collision is elastic and takes place in a time interval of 0.2s, with an average force of 100N. What was the speed, in m/s, of the glider?

a. 0.1
b. 1
c. 2
d. 4
e. 10

3. A man fell out of an airplane and barely survived. He was moving at a speed of 100m/s just before landing in deep snow on a mountain side. Experts estimated that the average net force on him was 600 N as he plowed through the snow for 10 s. What was his mass, in kg?

a. 150

b. 60

c. 90

d. 120

e. 110

4. A skier starts from rest and slides down from a high hill and then, without losing energy, up a smaller hill. His speed is 10m/s at the top of the smaller hill. Ignore friction. What was the difference in height of the two hills, in m?

a) Impossible to tell without knowing the mass of the skier and/or the shape of the slope

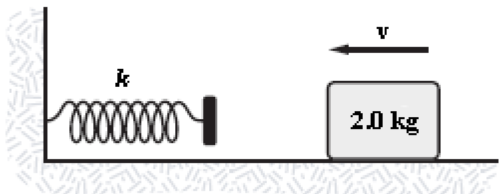
b) 2.5

c) 0.51

d) 5.1

e) 10.2

5. A block slides with no friction and hits a spring with spring constant k=2000 N/m. The block compresses the spring in a straight line for a distance 0.15m. The block's kinetic energy, in J, at that point is 0 J. What was its initial kinetic energy, in Joules?



a. 22

b. 19

c. 45

d. 29

e. 200

6. An elevator and counterweight are like Atwood's machine. An elevator, M=100kg, has a counter weight m=90kg connected by a cable over a massless pulley with no friction. The elevator falls, starting from rest, a distance 20.5 m and lands. What the final kinetic energy of the system, in J, just before the elevator lands?

a. 20,000
b. 18,000
c. 2000
d. 1800
e. 200

7. A mass is revolving in a horizontal circle. The circle has radius of 0.050 m. The mass has a linear speed of 0.63 m/s. What is the period, in seconds?

   a. 0.5
   b. 0.3
   c. 0.2
   d. 0.05
   e. 3.1

8. A small ball is attached to one end of a rigid rod with negligible mass. The ball and the rod revolve in a horizontal circle with the other end of the rod at the center. The path of the ball has a constant linear speed. The force exerted by the rod is 0.5 N. The centripetal acceleration is 0.5 m/s^2. What is the mass of the ball, in kg?

   a. Unknown: Need R
   b. .5
   c. 10
   d. 0.05
   e. 1

9. A ball is revolving horizontally in a circle and is held by a rigid, massless rod. The mass of the ball is 0.1 kg. The path of the ball has an angular velocity of 15 rad/s and a constant linear speed of 27 m/s. What is the radius of the orbit in m?

   a. 1.8
   b. 2.3
   c. 0.6
   d. 5.4
   e. 0.1

10. A car goes around a curve and then around another curve. The parameters are the following:
1st, force F1 with radius R and speed v.
2nd, force F2 with radius 6R and speed 3v.
What is the ratio of the centripetal forces, F1/F2?

a. 0.67

b. 1.3

c. 1

d. 2

e. 0.33

11. A person is on a circular carnival ride (“Ferris Wheel”) that goes up and down with an axis of rotation parallel to the ground. It makes her feel twice her normal weight at the bottom and weightless at the top. Her centripetal acceleration is constant. What is its value, in m/s?

a. 0
b. 2.4
c. 4.9
d. 19.6
e. 9.8

12. A toy train of m=0.60 kg moves at 20m/s along a straight track. It bumps into another train of M=1.5kg moving in the same direction. They stick together and continue on the track at a speed 12 m/s. What was the speed in m/s of the second train just before the collision?

a. 12

b. 1.1

c. 8.8

d. 42

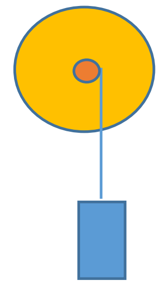
e. 9.2

13. A small ball is rotating in a circular horizontal path. The ball is held by a rigid, massless rod. Its angular rate of rotation is 4.00 rad/s. The kinetic energy of the ball is 19.2 J. What is the moment of inertia of the ball with respect to the axis of rotation, in kg m^2?
    a. 1.2
    b. 2.4
    c. 4.9
    d. 9.7
    e. 38

14. A small ball is rotating in a horizontal circular path on a massless, rigid wire around a vertical post. The radius of the ball's orbit is 1.2 m. The moment of inertia of the center of mass of the ball about the axis of rotation is 8.6 kg m^2. What is the ball's mass, in kg?
    a. 7.2
    b. 6.0
    c. 3.1
    d. 4.2
    e. 17.

15. Three particles with M_1=2 kg, M_2=3 kg and M_3=5 kg are located, respectively, at $\mathbf{r}_1=\mathbf{i}+2\mathbf{j}$ (in meters), $\mathbf{r}_2=\mathbf{i}+3\mathbf{j}$ and $\mathbf{r}_3=2\mathbf{i}-2\mathbf{j}$ **.** Find the location of the center of mass. In m**.**
    a. $0.5\,\mathbf{i} - 2\mathbf{j}$
    b. $-0.5\,\mathbf{i} + 2\mathbf{j}$
    c. $1.5\,\mathbf{i} - 0.2\mathbf{j}$
    d. $1.5\,\mathbf{i} + 0.3\mathbf{j}$
    e. $0.5\,\mathbf{i} - 0.4\mathbf{j}$

16. A mass of M=1.0 kg pulls down vertically on a string that unwinds around a solid cylindrical rod attached to a disk, with a combined moment of inertia I=10 kg-m^2. The rod has a radius of r=0.1 m, the disk has or radius R=1m and the system is initially at rest. What is the angular acceleration (in radians/s^2) of the disk.



a. 0.098

b. 9.8

c. 2.1

d. 0.0025

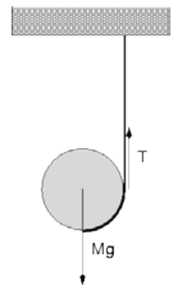
e. 0.49

17. A disk with mass M and radius R rolls down a 10 m long incline starting from rest. The incline makes 30 degrees with horizontal. Find its speed in m/s at the bottom of the incline.

    a. Need to know M and R
    b. 2
    c. 4
    d. 6
    e. 8

18. A disk (like a yoyo) starts from rest and falls down from the position shown in the figure, unwinding a light cord. The mass of the disk is M=26.7 kg, its radius is R=0.10 m.

What is the initial angular acceleration, α, of the disk, in rad/s^2?



a. 100

b. 65

c. 200

d. 9.8

e. 40

19. To determine how well a bicycle wheel is lubricated, the mechanic in the repair shop gives it a spin, measuring the time *t* before it stops and counting the number of revolutions *N*. If *t=1 min* and *N=100* revolutions, what is the magnitude of angular deceleration in rad/s^2?

a. 8.5

b. 0.05

c. 2.3

d. 0.35

e. 3.2

20. An Atwood machine, similar to an elevator, with a counter-weight, is initially at rest. On one side is a mass of 2.00 kg and on the other side is a mass of 1.00 kg. A massless cord that passes over a pulley connects the two weights. The pulley has a mass of 4.00 kg, a radius of 20.0 cm and no friction, and can be treated as a uniform disk. When the heavier mass has fallen for 50.0 cm, what is its linear speed, in m/s?

   a. 14
   b. 4
   c. 3.4
   d. 1.28
   e. 1.4

Consta**nts:** 1 inch = 2.54 cm; 1 mi =1.61 km; 1 cm=10^{-2}m; 1 mm= 10^{-3} m; 1 gram=10^{-3} kg;
$g = 9.8$ m/s^2 ; $G = 6.674\times10^{-11}$ N m^2/kg^2 ; $M_{Earth} = 5.97\times10^{24}$ kg ; $R_{Earth} = 6.37\times10^{6}$ m

1D and 2D motion: $x=x_i+vt$ (constant v);
$x = x_i + v_i t + \frac{1}{2}at^2$; $v = v_i + at$; $v^2 = v_i^2 + 2a(x - x_i)$; $\vec{r} = \vec{r}_i + \vec{v}_i t + \frac{1}{2}\vec{a}t^2$; $\vec{v} = \vec{v}_i + \vec{a}t$

Circular motion: $T = 2\pi R / v$; $T = 2\pi / \omega$; $a_c = v^2 / R$

Force: $\sum \vec{F} = m\vec{a}$; $\vec{F}_{12} = -\vec{F}_{21}$; **Friction:** $f_s \le \mu_s N$; $f_k = \mu_k N$

Energies: $K = \frac{1}{2}mv^2$; $U_g = mgy$; $U_s = \frac{1}{2}kx^2$; $W = \int \vec{F}\cdot d\vec{r} = \vec{F}\cdot\Delta\vec{r}$

$E_{total} = K + U_g + U_S$; $\Delta E_{mech} = \Delta K + \Delta U_g + \Delta U_s = -f_s d$; $P = dW/dt = \vec{F}\cdot\vec{v}$; $\Delta K = W$

Momentum and Impulse: $\vec{p} = m\vec{v}$; $\vec{I} = \int \vec{F}dt = \Delta\vec{p}$

Center of mass: $\vec{r}_{cm} = \sum_i m_i\vec{r}_i / \sum_i m_i$; $\vec{v}_{cm} = \sum_i m_i\vec{v}_i / \sum_i m_i$

Collisions: $\vec{p}$ = const and E≠ const (inelastic) or $\vec{p}$ = const and E= const (elastic)

Rotational motion: $\omega = 2\pi / T$; $\omega = d\theta / dt$; $\alpha = d\omega / dt$; $v_t = r\omega$; $a_t = r\alpha$
$a_c = a_r = v_t^2 / r = \omega^2 r$; $a_{tot}^2 = a_r^2 + a_t^2$; $v_{cm} = r\omega$ (rolling, no slipping) ; $a_{cm} = r\alpha$
$\omega = \omega_o + \alpha t$; $\theta_f = \theta_i + \omega_o t + \alpha t^2 / 2$; $\omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i)$; $\theta - \theta_i = \frac{\omega_0 + \omega}{2} t$
$I_{point} = MR^2$; $I_{hoop} = MR^2$; $I_{disk} = MR^2/2$; $I_{sphere} = 2MR^2/5$; $I_{shell} = 2MR^2/3$;
$I_{rod(center)} = \langle ML^2/12 \rangle$
$I_{rod(end)} = ML^2/3$; $I = \sum_i m_i r_i^2$; $I = I_{cm} + Mh^2$; $\vec{\tau} = \vec{r}\times\vec{F}$; $\sum \tau = I\alpha$; $\vec{L} = \vec{r}\times\vec{p}$; $\vec{L} = I\vec{\omega}$

Energy: $K_{rot} = I\omega^2/2$; $K = K_{rot} + K_{cm}$; $\Delta K + \Delta U = 0$; $W = \tau\,\Delta\theta$; $P_{inst} = \tau\omega$

Fluid: $\rho = \frac{M}{V}$; $P = P_o + \rho g h$; $A_1 v_1 = A_2 v_2$;
$P_1 + \rho g y_1 + \frac{1}{2}\rho(v_1)\hat{}2 = P_2 + \rho g y_2 + \frac{1}{2}\rho(v_2)\hat{}2$; $B = \rho_{fluid} V^{object} g$

Gravitation: $\vec{F}_g = -\frac{Gm_1m_2}{r^2}\hat{r}_{12}$; $g(r) = GM/r^2$; $U = -Gm_1m_2/r$; $T^2 = \frac{4\pi^2}{GM}a^3$

Math: 360° = 2π rad = 1 rev; Arc: $s = r\theta$; $V_{sphere} = 4\pi R^3/3$; $A_{sphere} = 4\pi R^2$; $A_{circle} = \pi R^2$

quadratic formula to solve $ax^2 + bx + c = 0$: $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Vectors: $\vec{A} = A_x\hat{i} + A_y\hat{j}$; $A_x = |\vec{A}|\cos(\theta)$; $A_y = |\vec{A}|\sin(\theta)$; $|\vec{A}| = \sqrt{A_x^{\,2} + A_y^{\,2}}$; $\tan\theta = \frac{A_y}{A_x}$

$\vec{C} = \vec{A} + \vec{B}$ => $C_x = A_x + B_x$; $C_y = A_y + B_y$;
$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta = A_xB_x + A_yB_y + A_zB_z$; $\hat{\imath}\cdot\hat{\imath} = \hat{\jmath}\cdot\hat{\jmath} = \hat{k}\cdot\hat{k} = 1$; $\hat{\imath}\cdot\hat{\jmath} = \hat{\imath}\cdot\hat{k} = \hat{\jmath}\cdot\hat{k} = 0$
$|\vec{A}\times\vec{B}| = |\vec{A}||\vec{B}|\sin\theta$; $\vec{A}\times\vec{B} = \hat{i}(A_yB_z - A_zB_y) + \hat{j}(A_zB_x - A_xB_z) + \hat{k}(A_xB_y - A_yB_x)$
$\hat{i}\times\hat{i} = \hat{j}\times\hat{j} = \hat{k}\times\hat{k} = 0$; $\hat{i}\times\hat{j} = \hat{k}$; $\hat{j}\times\hat{k} = \hat{i}$; $\hat{k}\times\hat{i} = \hat{j}$