Version A

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

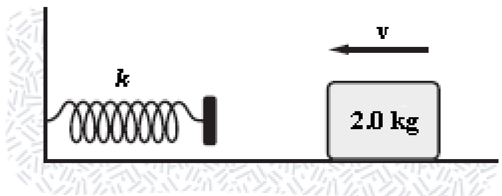
b) 2.5

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

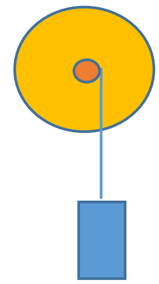
e. 9.2

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 $\mathbf{r}_1$=**i**+2**j** (in meters), $\mathbf{r}_2$=**i**+3**j** and $\mathbf{r}_3$=2**i**-2**j** **.** Find the location of the center of mass. In m**.**
    a. 0.5 **i** – 2**j**
    b. -0.5 **i** + 2**j**
    c. 1.5 **i** – 0.2**j**
    d. 1.5 **i** + 0.3**j**
    e. 0.5 **i** – 0.4**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

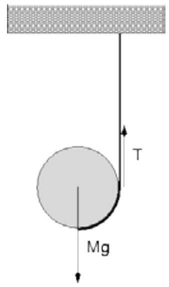
e. 0.49

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: $\rho = \frac{M}{V}$ **;** $P = P_o + \rho gh$ **;** $A_1 v_1 = A_2 v_2$**;**

$P_1 + \rho g y_1 + \frac{1}{2}\rho(v_1)$^2 $= P_2 + \rho g y_2 + \frac{1}{2}\rho(v_2)$^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: $\vec{A} = A_x\hat{i} + A_y\hat{j}$; $A_x = |\vec{A}|\cos(\theta)$; $A_y = |\vec{A}|\sin(\theta)$; $|\vec{A}| = \sqrt{A_x{}^2 + A_y{}^2}$; $\tan\theta = \frac{A_y}{A_x}$

$\vec{C} = \vec{A} + \vec{B}$ => $C_x = A_x + B_x$; $C_y = A_y + B_y$;

$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta = A_xB_x + A_yB_y + A_zB_z$ **;** $\hat{\imath}\cdot\hat{\imath} = \hat{\jmath}\cdot\hat{\jmath} = \hat{k}\cdot\hat{k} = 1$ **;** $\hat{\imath}\cdot\hat{\jmath} = \hat{\imath}\cdot\hat{k} = \hat{\jmath}\cdot\hat{k} = 0$

$|\vec{A}\times\vec{B}| = |\vec{A}||\vec{B}|\sin\theta$; $\vec{A}\times\vec{B} = \hat{i}(A_yB_z - A_zB_y) + \hat{j}(A_zB_x - A_xB_z) + \hat{k}(A_xB_y - A_yB_x)$

$\hat{i}\times\hat{i} = \hat{j}\times\hat{j} = \hat{k}\times\hat{k} = 0$ **;** $\hat{i}\times\hat{j} = \hat{k}$ **;** $\hat{j}\times\hat{k} = \hat{i}$ **;** $\hat{k}\times\hat{i} = \hat{j}$

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Physics 111 **Exam 1**

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Signature: ____

1. A student is driving a car at 60.0 miles/hr. What is its speed in m/s? There are 3.28 feet in a meter and 5280 feet in a mile.
    a. 2.24
    b. 27
    c. 134
    d. 45
    e. 23

2. How many million gallons of blood does a human heart pump in an average lifetime? The average number of beats in a lifetime is about 3000 million and the volume pumped with each beat is about 50 cm^3. A gallon is 3800 cm^3.
    a. 39
    b. 228,000
    c. 150,000
    d. 0.79
    e. 47

3. Car A starts 10 meters ahead of car B. Car A moves at $\mathbf{v}_A$=(3.0 **i** +0 **j**) m/s and Car B moves forward at $\mathbf{v}_B$=(7.0 **i** + 0 **j**) m/s. How many seconds does it take car B to catch up?
    a. 2.5
    b. 3.3
    c. 1.4
    d. 10
    e. 7

4. An airplane accelerates with (7.33 **i**+ 0 **j**) m/s^2 from an initial velocity (200 **i** + 0 **j**) m/s for a distance of (1.20 **i** + 0 **j**)km. What is the final velocity in m/s?
   a. (440 **i** + 200 **j**)
   b. (500 **i** + 0 **j**)
   c. (240 i + 0 j)
   d. (240 i + 200 j)
   e. (200 i + 240 j)

5. A car drives carrying a flag of width w=0.5m. When the flag goes through a photogate, it blocks and unblocks a light. If the average speed of the car is 20m/s, what is the photogate time interval in seconds?
   a. 40
   b. 4
   c. 0.25
   d. 0.025
   e. 0.01

6. A jet test pilot can accelerate at "5g" (5x9.8 m/s^2). At that acceleration she will black out in 5 s. She plans to start from rest and to speed up to Mach 3 (3x331m/s). How long (in s) would this part of her planned flight take, if she can do it?
   a. 20
   b. 15
   c. 200
   d. 4
   e. 1

7. A military jet first flies in one direction, turns sharply and then flies in another, as described by the vectors: **A**=2**i**+4**j**; **B**=5**i**-3**j**. Take the x-axis as east and find the angle in degrees of the sum of these motions relative to east.
   a. 4
   b. 8
   c. 10
   d. 82
   e. 352

8. A car slows down because of traffic and has an acceleration of -1.0 m/s^2. After moving for 6.0 m, it has a velocity of 4.0 m/s. What was its initial velocity?
   a. 2
   b. 16
   c. 5.3
   d. 15
   e. 3.8

9. A car drives off a cliff next to a river at a speed of 30 m/s and lands on the bank on the other side. The road above the cliff is horizontal and 8.3 m above the other shore where the car lands. The tires on the car all hit at once and the air resistance is insignificant. How long is the car in the air?
   a. 1.3
   b. 0.92
   c. 0.76
   d. 0.45
   e. 2.2

10. The launch angle of a projectile is 30 degrees and its velocity in the x direction is 1.7 m/s after 2s. Neglecting friction, what is the initial magnitude of the projectile's velocity along its firing direction?
    a. 0
    b. 1.7
    c. 0.6
    d. 2
    e. 3.4

11. A rocket-launching vehicle is moving forward at a constant velocity of 5 m/s. A cannon on the vehicle shoots a shell straight up with a velocity of 20 m/s. The shell moves without friction, (no air resistance). How high does the shell go, in m?
    a. 1
    b. 10
    c. 40
    d. 2.0
    e. **20**.

12. A second launching vehicle is moving forward at 5m/s and its cannon shoots a shell straight up. The shell moves through the air without friction for 2s. How far, in m, in front of the cannon does the shell land?
    a. 10.
    b. 40.
    c. -10.
    d. 0
    e. 20.

13. A quarterback throws a football at a speed of 32.1 m/s at an angle 41.2 degrees. What horizontal distance in m can he throw it down field is if wind and air resistance are insignificant?
    a. 52
    b. 104
    c. 77.3
    d. 42.2
    e. 25.7

14. A plane in level flight at 98 m/s at an altitude of 935 m drops a package. Find the speed in m/s with which the package lands.
    a. 940
    b. 167
    c. 336
    d. 98
    e. 233

15. A bean fills a volume of 3.0 mm^3 . To compare the size of a bean with a large container, what is the volume of the bean in units of m^3 ?
    a. 0.003 m^3
    b. 0.027 m^3
    c. 3×10^{-6} m^3
    d. 3×10^{-9} m^3
    e. 3×10^{9} m^3

16. A speeding car moving at constant speed of 60 m/s passes a policeman who immediately starts his motorcycle (from rest) and accelerates at 2 m/s^2. How long, in seconds, will it take the policeman to catch up with the car?
    a. 20
    b. 30
    c. 60
    d. 80
    e. 120

17. Another car moving at a constant speed of 60m/s passes a policeman who starts his motorcycle (from rest) in 10 seconds and then accelerates at 2 m/s^2. How far, in meters, from the original point will it catch up with the car?
    a. 1700
    b. 2700
    c. 3700
    d. 4700
    e. 5700

18. A drone is in level flight at a speed of 201 m/s and an altitude of 802 m. At what horizontal distance, in m, from the target should the remote pilot drop an aid package so it lands on target?
    a. 257
    b. 375
    c. 890
    d. 1560
    e. 2570

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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) ; $a_{cm} = r\alpha$
$\omega = \omega_o + \alpha t$; $\theta_f = \theta_i + \omega_o t + \alpha t^2 / 2$; $\omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i)$
$I_{point} = MR^2$; $I_{hoop} = MR^2$; $I_{disk} = MR^2 / 2$; $I_{sphere} = 2MR^2 / 5$; $I_{shell} = 2MR^2 / 3$;
$I_{rod(center)} = \langle ML^2 / 12 \rangle$
$I_{rod(end)} = ML^2 / 3$; $I = \sum_i m_i r_i^2$; $I = I_{cm} + Mh^2$; $\vec{\tau} = \vec{r}\times\vec{F}$; $\sum \tau = I\alpha$; $\vec{L} = \vec{r}\times\vec{p}$; $\vec{L} = I\vec{\omega}$

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

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: $\vec{A} = A_x\hat{i} + A_y\hat{j}$; $A_x = |\vec{A}|\cos(\theta)$; $A_y = |\vec{A}|\sin(\theta)$; $|\vec{A}| = \sqrt{A_x^2 + A_y^2}$; $\tan\theta = \frac{A_y}{A_x}$
$\vec{C} = \vec{A} + \vec{B}$ => $C_x = A_x + B_x$; $C_y = A_y + B_y$;
$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta = A_xB_x + A_yB_y + A_zB_z$; $\hat{\imath}\cdot\hat{\imath} = \hat{\jmath}\cdot\hat{\jmath} = \hat{k}\cdot\hat{k} = 1$; $\hat{\imath}\cdot\hat{\jmath} = \hat{\imath}\cdot\hat{k} = \hat{\jmath}\cdot\hat{k} = 0$
$|\vec{A}\times\vec{B}| = |\vec{A}||\vec{B}|\sin\theta$; $\vec{A}\times\vec{B} = \hat{\imath}(A_yB_z - A_zB_y) + \hat{\jmath}(A_zB_x - A_xB_z) + \hat{k}(A_xB_y - A_yB_x)$
$\hat{\imath}\times\hat{\imath} = \hat{\jmath}\times\hat{\jmath} = \hat{k}\times\hat{k} = 0$; $\hat{\imath}\times\hat{\jmath} = \hat{k}$; $\hat{\jmath}\times\hat{k} = \hat{\imath}$; $\hat{k}\times\hat{\imath} = \hat{\jmath}$

Name (print neatly):______________________________Section #:_____

Physics 111 **Exam 2**

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 study 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: ____

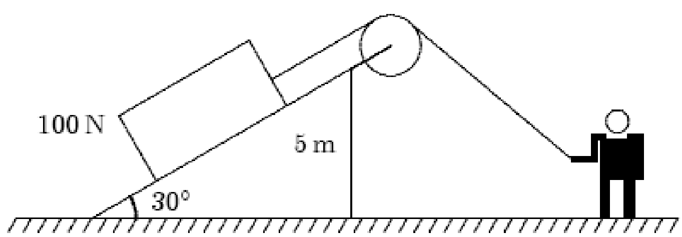
1. Two blocks are on a horizontal, frictionless table. A force of 2.0 N pulls a block that has m=3.0 kg. The block is connected to a second block, M=4.0 kg, by a wire. What is the tension, in N, in the wire?
   - **a. 1.1**
   - b. 0.86
   - c. 0.29
   - d. 2.0
   - e. 1.0

2. A beam is tilted up by 0.02 m at one end, and it is 1m long. Friction is insignificant. Mass of the glider is 1 kg. What is the magnitude of the component of net force, in N, acting on the glider along the beam.
   - a. 100
   - b. 2
   - c. 5
   - d. 0.02
   - **e. 0.2**

3. An elevator of mass 1000 kg pulls down on one side of a cable that goes over a pulley that has no friction. A counter weight of 900 kg pulls on the other side. The elevator starts to fall with no friction. What is the net force on the system, in N? Take the elevator's direction of motion as positive.
   - a. 50
   - **b. 980**
   - c. 100
   - d. 460
   - e. 20

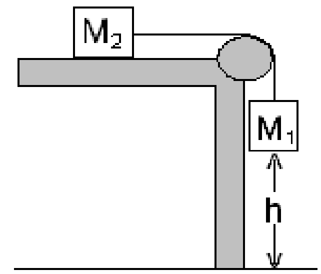
4. On a Force table, forces are applied to a small ring near the center. If the forces are *F1*=-0.9 **i** +0 **j** and F2=0 **i** -0.75 **j** , what is the magnitude, in N, of a third force which will keep the ring in equilibrium without touching the pin at the center?
a. **1.2**
b. 1.6
c. 1.4
d. 0.9
e. 0.6

5. A crate of weight 100-N is sitting on a ramp with a 30 degree slope, as shown. The playful man lets go and the crate slides down with no friction and an acceleration a1. He then places another crate of half the weight on the ramp. Again, he lets go and the second crate slides down with acceleration a2. What are values of a1 and a2 in m/s^2?
a. 9.8, 4.9
b. 4.9, 2.5
c. 9.8, 9.8
d. 4.9, 9.8
e. 4.9, 4.9



6. The man lets go of the rope attached to the 100-N crate. It starts from rest and slides down the 30-degree slope with no friction. The crate's velocity increases to 9.8 m/s at a time t. What is t in s?
   a. 9.8
   b. 0.01
   c. 0.3
   d. 2.0
   e. 9.8

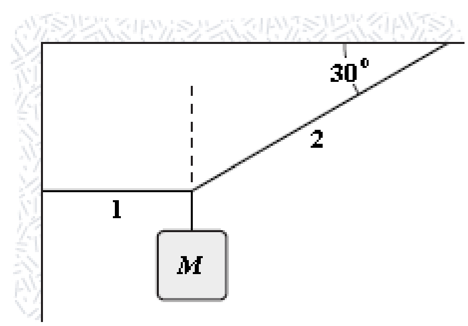
7. Two masses M_1 = 2 kg and M_2 = 4 kg are attached by a string as shown. They start from rest and move with no friction until they reach a velocity of 6.5 m/s. When do they reach that speed, in s ?



   a. 0.68
   b. 4.3
   c. 2.0
   d. 1.4
   e. 3.3

8. "A light fixture of mass 3.55 kg hangs by two wires (arranged like a "Y"), each of which makes an angle of 10 degrees with the ceiling. What is the tension, in N, in one of the wires?
   a. 200
   b. 100
   c. 25
   d. 20
   e. 10

9. A light fixture is suspended from a wall and a ceiling by wires, as shown. The tension, T1 in wire 1 is 3.5 N. What is the mass, M, in kg?



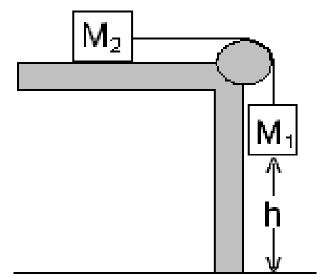
   a. 3.4;
   b. 2.0
   c. 1.7
   d. 0.64
   e. 0.21

10. A block sits on a horizontal surface with a coefficient of static friction of 0.2 between them. A horizontal force of 14 N is just able to move the block parallel to the surface.
What is the mass, in kg, of the block?

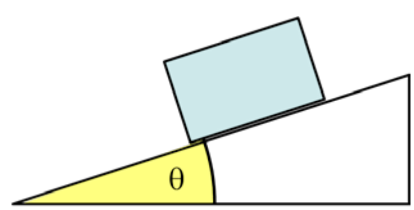
   a. **7.1**
   b. 14
   c. 70
   d. 1.4
   e. 3.5

11. Two masses are attached by a string as shown. The mass, M_2 , is 4 kg and the coefficient of friction is 0.5. What is the maximum mass M_1 , in kg, that allows the system to stay at rest?

   a. 0.3
   b. **2**
   c. 4
   d. 0.5
   e. 8



12. The block is at rest. Then, the ramp is gradually tilted. At at an angle of 14 degrees, the block begins to slide. What is the coefficient of static friction between the block of unknown mass, m, and the ramp?
   a. Can’t tell; need m
   b. 0.87
   c. 0.61
   d. 0.55
   e. **0.25**



13. A woman pulls a block along a horizontal surface at a constant speed with a 15-N force acting 20° above the horizontal. She does 85 J of work. How many meters does the block move?

a. 5.6

b. 90

c. 6.0

d. 0.16

e. 3

14. A person does 200 J work lifting an object from the bottom of a well at a constant speed of 2.0 m/s in a time of 5.1 s. What is the object's mass? (Neglect friction.)

a. 20

b. 2.0

c. 6.2

d. 2.1

e. 4.0

15. A woman throws a 2.0-kg ball from the origin to a point at (20 **i** + 3 **j** + h k) meters, where **k** is the upward unit vector. The work done by the gravitational force on the ball is -290J. What is the height, h?

a. 19

b. 15

c. 39

d. 7

e. 150

16. Suddenly, the driver of a fast car travelling 50 m/s sees a deer and slams on the brakes. The car travels for 10 s before it stops. What is the coefficient of kinetic friction between the tires and the road?

a. 0.13
b. 0.26
c. 0.32
d. 0.41
e. 0.51

17. An object falls vertically downward in water at a constant speed. The viscosity of the water does work of -20 J as the object falls 0.80 m. What is the mass, in kg, of the object?

a. 2.0
b. 20
c. 3.7
d. 2.6
e. 1.7

18. A constant force of (2 **i** -15 **j + 2 k**) N acts on a particle as it moves from the origin to a point (4 **i** + 3 **j + 5 k**) m. How much work, in J, does the force do during this displacement?

a. +30
b. –27
c. +45
d. –45
e. +37

19. A CONSTANT force acts on an object and increases its kinetic energy, by 24 J. The object moves from (7 **i** -8 **j** +4 k)m to (11 **i** – 5 **j** + 4 **k**) m. The net force acting on the object is equal to (Fx **i** + 4 **j** + 5 **k**) N. What is Fx, in N.

a. 1

b. -4

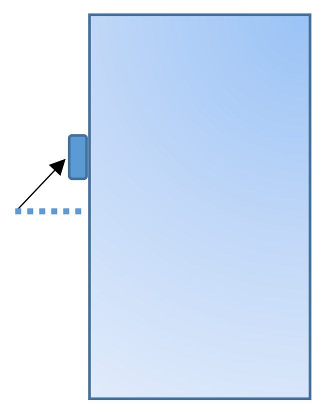
c. 4

d. 3

e. -3

20. As shown in the figure, a block is pushed up against a vertical wall by a force 20 N. The force is at an angle of 40 degrees from horizontal. The coefficient of static friction between the block and the wall is 0.50. Find the maximum mass, in kg, that the force can prevent from sliding down.

a. Infinite
b. 0.92
c. 2.1
d. 0.52
e. 10



Constants: 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) ; $a_{cm} = r\alpha$
$\omega = \omega_o + \alpha t$; $\theta_f = \theta_i + \omega_o t + \alpha t^2 / 2$; $\omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i)$
$I_{point} = MR^2$; $I_{hoop} = MR^2$; $I_{disk} = MR^2/2$; $I_{sphere} = 2MR^2/5$; $I_{shell} = 2MR^2/3$;
$I_{rod(center)} = \langle ML^2 / 12 \rangle$
$I_{rod(end)} = ML^2/3$; $I = \sum_i m_i r_i^2$; $I = I_{cm} + Mh^2$; $\vec{\tau} = \vec{r}\times\vec{F}$; $\sum \tau = I\alpha$; $\vec{L} = \vec{r}\times\vec{p}$; $\vec{L} = I\vec{\omega}$

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

Gravitation: $\vec{F}_g = -\frac{Gm_1 m_2}{r^2}\hat{r}_{12}$; $g(r) = GM / r^2$; $U = -Gm_1 m_2 / r$; $T^2 = \frac{4\pi^2}{GM}a^3$

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: $\vec{A} = A_x\hat{i} + A_y\hat{j}$; $A_x = |\vec{A}|\cos(\theta)$; $A_y = |\vec{A}|\sin(\theta)$; $|\vec{A}| = \sqrt{A_x{}^2 + A_y{}^2}$; $\tan\theta = \frac{A_y}{A_x}$
$\vec{C} = \vec{A} + \vec{B}$ => $C_x = A_x + B_x$; $C_y = A_y + B_y$;
$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta = A_x B_x + A_y B_y + A_z B_z$; $\hat{\imath}\cdot\hat{\imath} = \hat{\jmath}\cdot\hat{\jmath} = \hat{k}\cdot\hat{k} = 1$; $\hat{\imath}\cdot\hat{\jmath} = \hat{\imath}\cdot\hat{k} = \hat{\jmath}\cdot\hat{k} = 0$
$|\vec{A}\times\vec{B}| = |\vec{A}||\vec{B}|\sin\theta$; $\vec{A}\times\vec{B} = \hat{\imath}(A_y B_z - A_z B_y) + \hat{\jmath}(A_z B_x - A_x B_z) + \hat{k}(A_x B_y - A_y B_x)$
$\hat{\imath}\times\hat{\imath} = \hat{\jmath}\times\hat{\jmath} = \hat{k}\times\hat{k} = 0$; $\hat{\imath}\times\hat{\jmath} = \hat{k}$; $\hat{\jmath}\times\hat{k} = \hat{\imath}$; $\hat{k}\times\hat{\imath} = \hat{\jmath}$

Version A

Name (print neatly):______________________________Section #:_____

Physics 111 **Exam 1**

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/14 questions=5 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.
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6. If any question is unclear, ask a tutor to clarify it immediately.
7. Use a calculator.
8. Answers are rounded to the significant figures.

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. A student is driving a car at 60.0 miles/hr. What is its speed in m/s? There are 3.28 feet in a meter and 5280 feet in a mile.
    a. 2.24
    b. 27
    c. 134
    d. 45
    e. 23

2. How many million gallons of blood does a human heart pump in an average lifetime? The average number of beats in a lifetime is about 3000 million and the volume pumped with each beat is about 50 cm^3. A gallon is 3800 cm^3.
    a. 39
    b. 228,000
    c. 150,000
    d. 0.79
    e. 47

3. Car A starts 10 meters ahead of car B. Car A moves at $\mathbf{v}_A$=(3.0 **i** +0 **j**) m/s and Car B moves forward at $\mathbf{v}_B$=(7.0 **i** + 0 **j**) m/s. How many seconds does it take car B to catch up?
    a. 2.5
    b. 3.3
    c. 1.4
    d. 10
    e. 7

4. An airplane accelerates with (7.33 **i**+ 0 **j**) m/s^2 from an initial velocity (200 **i** + 0 **j**) m/s for a distance of (1.20 **i** + 0 **j**)km. What is the final velocity in m/s?
   a. (440 **i** + 200 **j**)
   b. (500 **i** + 0 **j**)
   c. (240 i + 0 j)
   d. (240 i + 200 j)
   e. (200 i + 240 j)

5. 32 A car drives carrying a flag of width w=0.5m. When the flag goes through a photogate, it blocks and unblocks a light. If the average speed of the car is 20m/s, what is the photogate time interval in seconds?
   a. 40
   b. 4
   c. 0.25
   d. 0.025
   e. 0.01

6. A jet test pilot can accelerate at "5g" (5x9.8 m/s^2). At that acceleration she will black out in 5 s. She plans to start from rest and to speed up to Mach 3 (3x331m/s). How long (in s) would this part of her planned flight take, if she can do it?
   a. 20
   b. 15
   c. 200
   d. 4
   e. 1

7. 29 A military jet first flies in one direction, turns sharply and then flies in another, as described by the vectors: **A**=2**i**+4**j**; **B**=5**i**-3**j**. Take the x-axis as east and find the angle in degrees of the sum of these motions relative to east.
   a. 4
   b. 8
   c. 10
   d. 82
   e. 352

8. A car slows down because of traffic and has an acceleration of -1.0 m/s^2. After moving for 6.0 m, it has a velocity of 4.0 m/s. What was its initial velocity?
   a. 2
   b. 16
   c. 5.3
   d. 15
   e. 3.8

9. 43 A car drives off a cliff next to a river at a speed of 30 m/s and lands on the bank on the other side. The road above the cliff is horizontal and 8.3 m above the other shore where the car lands. The tires on the car all hit at once and the air resistance is insignificant. How long is the car in the air?
   a. 1.3
   b. 0.92
   c. 0.76
   d. 0.45
   e. 2.2

10. 32 The launch angle of a projectile is 30 degrees and its velocity in the x direction is 1.7 m/s after 2s. Neglecting friction, what is the initial magnitude of the projectile's velocity along its firing direction?
    a. 0
    b. 1.7
    c. 0.6
    d. 2
    e. 3.4

11. 9 A rocket launching vehicle is moving forward at a constant velocity of 5 m/s. A cannon on the vehicle shoots a shell straight up with a velocity of 20 m/s. The shell moves without friction, (no air resistance). How high does the shell go, in m?
    a. 1
    b. 10
    c. 40
    d. 2.0
    e. **20**.

12. 31 A second launching vehicle is moving forward at 5m/s and its cannon shoots a shell straight up. The shell moves through the air without friction for 2s. How far, in m, in front of the cannon does the shell land?
    a. 10.
    b. 40.
    c. -10.
    d. 0
    e. 20.

13. A quarterback throws a football at a speed of 32.1 m/s at an angle 41.2 degrees. How far, in m, can he throw it if the wind and air resistance are insignificant?
    a. 105.1
    b. 52.2
    c. 77.3
    d. 42.2
    e. 25.7

14. A drone is in level flight at a speed of 200 m/s and an altitude of 800 m. At what horizontal distance, in m, from the target should the remote pilot drop an aid package so it lands on target?
    a. 257
    b. 375
    c. 890
    d. 1560
    e. 2560
15. For the previous problem, find the speed in m/s with which the package lands on target
    a. 136
    b. 236
    c. 336
    d. 436
    e. 536

16. Express volume of 3.0 mm^3 in m^3 .
    a. 0.003 m^3
    b. 0.027 m^3
    c. 3 x 10^{-6} m^3
    d. 3 x 10^{-9} m^3
    e. 3 x 10^{-12} m^3

17. A speeding car moving at constant speed of 60 m/s passes a policeman who immediately starts his motorcycle (from rest) and accelerates at 2 m/s/s. How long, in seconds, will it take to catch up with the car?
    a. 20
    b. 40
    c. 60
    d. 80
    e. 100

18. Same problem as above, but it takes extra 10 seconds to start the motorcycle from rest. How far, in meters, from the original point will it catch up with the car?
    a. 1724
    b. 2724
    c. 3724
    d. 4724
    e. 5724

19. Vectors **A** and **B** are given by **A**=1.73**i**+**j**, **B**=2**i**+3.46**j** . Find the angle between **A** and **B** (in degrees)
    a. 15
    b. 30
    c. 45
    d. 60
    e. 90

20. Find **C** such that **A**+**B**+**C**=0.
    a. -6**i+6j**
    b. 6**i-**6**j**
    c. -3.73**i**-4.46**j**
    d. 3.73**i**+4.46**j**
    e. 6**i**+2**j**

Constants: 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;
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1D and 2D motion: $x=x_i+vt$ (constant v);
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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:** $f_s \le \mu_s N$; $f_k = \mu_k N$

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

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

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

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

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: $\vec{A} = A_x\hat{i} + A_y\hat{j}$; $A_x = |\vec{A}|\cos(\theta)$; $A_y = |\vec{A}|\sin(\theta)$; $|\vec{A}| = \sqrt{A_x^2 + A_y^2}$; $\tan\theta = \frac{A_y}{A_x}$
$\vec{C} = \vec{A} + \vec{B}$ => $C_x = A_x + B_x$; $C_y = A_y + B_y$;
$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta = A_xB_x + A_yB_y + A_zB_z$; $\hat{\imath}\cdot\hat{\imath} = \hat{\jmath}\cdot\hat{\jmath} = \hat{k}\cdot\hat{k} = 1$; $\hat{\imath}\cdot\hat{\jmath} = \hat{\imath}\cdot\hat{k} = \hat{\jmath}\cdot\hat{k} = 0$
$|\vec{A}\times\vec{B}| = |\vec{A}||\vec{B}|\sin\theta$; $\vec{A}\times\vec{B} = \hat{\imath}(A_yB_z - A_zB_y) + \hat{\jmath}(A_zB_x - A_xB_z) + \hat{k}(A_xB_y - A_yB_x)$
$\hat{\imath}\times\hat{\imath} = \hat{\jmath}\times\hat{\jmath} = \hat{k}\times\hat{k} = 0$; $\hat{\imath}\times\hat{\jmath} = \hat{k}$; $\hat{\jmath}\times\hat{k} = \hat{\imath}$; $\hat{k}\times\hat{\imath} = \hat{\jmath}$