Name (print neatly): ______________________________ Section #:
_____

Physics 111      Fall 20xx      Final Exam

Contents: Entire course as in the Syllabus.

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: 150 minutes/30 questions=about 5 min each.
2. Questions vary in difficulty. Look for ones you can do first.
3. If you are stuck on a question, move on.
4. All answers are in standard units of m, s, kg, N and J.
5. If you show your work neatly on the exam sheet, you will do better.
6. If any question is unclear, ask a proctor to clarify it immediately.
7. Use a calculator and the equation sheet at the end, but no other electronics or notes.
8. Possible answers given are approximate; select the closest one to yours.

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 proctors will help.
1. **C** A plate is approximately a uniform disk. It has a moment of inertia of 10 kg m² and a mass of 5 kg. What is its radius, in m?
   a. 4
   b. 2
   c. 10
   d. 20
   e. 5

2. **C** A bicycle tire is shaped approximately like a ring and is ½ m in radius. When it spins with an angular momentum of 5 (kg m² radians/s), its angular speed is 2 radians/s. What is its mass, in kg?
   a. 1
   b. 2
   c. 5
   d. 20
   e. 10

3. **C** A ladybug sits at the outer edge of a merry-go-round, and a gentleman bug sits halfway between her and the axis of rotation. The merry-go-round makes a complete revolution once each second. The gentleman bug’s angular speed is

   1. half the ladybug’s.
   2. the same as the ladybug’s.
   3. twice the ladybug’s.
   4. impossible to determine
   5. 4 times the ladybug’s
4. A merry-go-round is rotating at an angular speed of 0.2 radians/s. Its motor falls off and it rotates freely. A technician jumps on the edge along the direction of the radius. The angular velocity after he lands is 0.04 radians/s. The moment of inertia of the technician, in (kg m²) with respect to the axis of the merry-go-round’s axis of rotation is 5000 kg m². What is the moment of inertia of the merry-go-round?

   a. 1000
   b. 2500
   c. 1250
   d. 625
   e. 20,000

5. A student drops a ring, centered on a rotating cylindrical table, as shown. Before the drop, the table has an angular momentum of 12 kg m² radians/s. The ring has a moment of inertia of 2.0 kg m² and the table has moment of inertia of 4.0 kg m². After the drop, the table and ring are rotating together with an angular momentum of 12 kg m² radians/s. What is the angular speed of the ring, in rad/s, before the drop?

   a. 12
   b. 2
   c. 4
   d. 8
   e. 0
6. C  A man balances a large rock of mass 300 kg whose center of mass is located at 0.5 m from a balance point (fulcrum). The man finds that he must stand 2.5 m from the fulcrum on the stiff board of negligible mass. What is the mass of the man, in kg?

   a. 2  
   b. 60  
   c. 150  
   d. 300  
   e. 600

7. B  Two children hop on a raft (of negligible mass) that is 4 m by 4 m. The girl, of mass 20 kg, stands at \( \mathbf{R}_1 = (2\mathbf{i}+0\mathbf{j}) \), relative to the center. A second girl, of mass 20 kg, stands at \( \mathbf{R}_2 = (0\mathbf{i}+2\mathbf{j}) \). A 3rd girl stands at \( \mathbf{R}_3 = (-2\mathbf{i} - 2\mathbf{j}) \) to balance the raft. What is her mass, in kg?

   a. 40  
   b. 20  
   c. 10  
   d. 5  
   e. 60
8. B A diver stands still on the free end of a diving board. The board is fixed at the other end. It has a support point, with a normal force of 1840 N located 1/3 of the distance from the fixed end. The diver weighs 481 N. The diving board is uniform. How much does it weigh, in N?

   a. 481
   b. 265
   c. 1090
   d. 745
   e. 1840

8. B A cable and a hinge point support a uniform beam in a horizontal position. The cable is at a 37.0-degree angle with the vertical, as shown in the figure. The beam weighs 120 N. What is the tension in the cable in N?

   a. 10
   b. 60
   c. 75
   d. 94
   e. 120
9. C A small ball is attached to one end of a massless, rigid rod. 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 mass of the ball is 3 kg. What is the centripetal acceleration of the ball, in m/s²?
   a. Unknown: Need R
   b. .5
   c. 10
   d. 0.05
   e. 0.17

10. C A ball is revolving horizontally in a circle of radius 1.8 m, and is held by a rigid, massless rod. The mass of the ball is 0.1 kg. The path of the ball has a constant linear speed of 27 m/s. What is the angular velocity of the orbit in rad/s?
   a. 15
   b. 2.3
   c. 0.6
   d. 5.4
   e. 0.1

11. C A car goes around a curve and then around another curve. The parameters are the following:
    1st, force F1 with radius R, mass m and speed v.
    2nd, force F2 with radius xR, mass m and speed 3v.
    The ratio of the centripetal forces, F1/F2 = 0.67. What is x?
   a. 6
   b. 1.3
   c. 1
   d. 2
   e. 3
12. C A person is riding on a circular carnival ride ("Ferris Wheel") that revolves with an axis of rotation parallel to the ground. Her centripetal acceleration is 9.8 m/s².

How heavy does she feel at the top and at the bottom?

   a. Twice her weight at the top and weightless at the bottom
   b. Twice and twice
   c. Weightless and equal
   d. Equal and twice
   e. Weightless and twice

13. C A technician fills a tank with a liquid to a height of 0.20 m. The tank is cylindrical with radius 0.10 m. The weight of the liquid is 10 N. What is the density of the liquid in kg/m³?

   a. 10
   b. 200
   c. 16
   d. 160
   e. 5

14. A A student measures the weight of a cylinder of Al in air and then with the cylinder immersed in a liquid. The weight in the liquid is 2 N and in air 3 N. The density of the fluid is 1700 kg/m³. What is the volume of the cylinder in m³?

   a. 0.027/1000
   b. 0.013/100
   c. 0.058/1000
   d. 0.032/1000
   e. 0.066/1000
15. C A doctor finds a partial blockage in a blood vessel. The flow speed in the region of the partial blockage is 5100 mm/hour. In a nearby vessel that is clear, the area is 0.51 mm². The blood flow speed, in mm/hr, in the clear region is 1200 mm/hr. What is the cross-section area, in mm², available for blood flow near the blockage?
   a. 0.46
   b. 0.51
   c. 0.23
   d. 0.12
   e. 0.06

16. C An astronaut of mass 51 kg on earth travels on a space ship to a distance of 7.5 times the earth’s radius from the center of the earth. What is her mass, in kg, at that distance from the earth?
   a. 51
   b. 500
   c. 67
   d. 8.9
   e. 6.8

17. C The magnitude of the gravitational field of a planet, is 320 N/kg at its surface. What is its gravitation field, in N/kg, at a distance from its center of 4 times its radius.
   a. 9.8
   b. 20
   c. 80
   d. 120
   e. 320
18. C An astronaut drops a ball of mass 1kg from a height of 1.5m on the surface of a planet with $g=33$ N/kg. For how long, in seconds, does the ball fall?
   a. 0.55
   b. 0.3
   c. 1.2
   d. 3.3
   e. 0.05

19. A An astronaut drops a ball on another planet where $g=6$N/kg from a height of 2 m. She measures the kinetic energy when the ball hits the planet’s surface to be 36 J. What is the mass of the ball?
   a. 4
   b. 6
   c. 1.5
   d. 3
   e. Can’t tell.

20. C A car has a speed of 10 m/s. It accelerates at a rate of 2.5 m/s$^2$ up to 17.5 m/s. How long did it take, in s?
   a. 0.25
   b. 0.14
   c. 4
   d. 7
   e. 3
21. C A Mercedes starts from rest and accelerates at 20 m/s² for 4 s. How far, in m, does it go?
   a. 8
   b. 40
   c. 80
   d. 160
   e. 320

22. C A man throws a ball and it reaches a height of 20 m. What was the initial speed in the y direction, in m/s, assuming no air drag?
   a. 3.3
   b. 14
   c. 20
   d. 33
   e. 100
23. A Two rocks are attached to each other by a string. The first rock is hanging over the edge of a table; the second rock with \( m = 4 \) kg sits on the top of the table with no friction. The string passes over a massless pulley (with no friction) between the rocks. Starting from rest, the rocks have a speed of 6.6 m/s after 2 s. What is the mass of the first rock, in kg?

a. 0.5
b. 1
c. 2
d. 4
e. 6.6

24. A A light fixture with \( m = 2.0 \) kg is suspended with 2 wires. One wire is from a wall and is horizontal with a tension = 37 N. What is the angle of the second wire relative to the (horizontal) ceiling?

a. 0
b. 20
c. 27
d. 37
e. 53
25. B A block is sitting on a ramp tilted from horizontal. The block is just about to slide. The angle of the ramp relative to horizontal is 14 degrees. What is the coefficient of friction between the block and the ramp?
   a. 0.25  
   b. 0.97  
   c. 0.5  
   d. 0.1  
   e. 0.34

26. C A block is pulled along a horizontal surface at a constant speed by a force (14.1i+0j+5.1k). The direction k is perpendicular to the surface. The block moves 6 m. How much work, in N m, does the force do?
   a. 115  
   b. 8.6  
   c. 14  
   d. 17  
   e. 85

27. B A skier with no initial speed skies straight down a hill 12 m high with no friction and then up a second hill. Her speed is 10 m/s, at the top of the second hill. How high, in m, is the second hill?
   a. 7  
   b. 5  
   c. 11.5  
   d. 2  
   e. 14
28. C A rifle shoots a projectile of mass 1 kg into a block. The speed of the projectile before it hits is 100 m/s. The projectile sticks in the block and they move together at 2 m/s. What is the mass of the block, in kg?
   a. 1
   b. 10
   c. 29
   d. 49
   e. 53

29. A A mass of 5.00 kg pulls down vertically on a string that is wound around a rod of radius 0.100 m and negligible moment of inertia. The rod is fixed in the center of a disk. The disk has mass 125 kg and radius 0.2 m. They turn freely about a fixed axis through the center. What is the angular acceleration of the rod, in radians/s²?
   a. 2
   b. 25
   c. 50
   d. 75
   e. 125
30. A A mass of 5kg starts from rest and pulls down vertically on a string wound around a disk-shaped, massive pulley. The mass of the disk is 5kg and its radius is 2 m. What is the linear speed, in m/s, after the mass drops by 0.3 m?
   a. 0.5
   b. 1.5
   c. 2
   d. 3
   e. 5
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;

\[ g = 9.8 \ m/s^2 \ ; \ G = 6.674 \times 10^{-11} \ N \ m^2/kg^2 \ ; M_{Earth} = 5.97 \times 10^{24} \ kg \ ; R_{Earth} = 6.37 \times 10^6 \ m \]

1D and 2D motion: \( x = x_i + vt \) (constant \( v \));

\[ x = x_i + v_i t + \frac{1}{2}at^2 \ ; \ v = v_i + at \ ; \ v^2 = v_i^2 + 2a(x-x_i) \ ; \ \vec{r} = \vec{r}_i + \vec{v}_i t + \frac{1}{2}at^2 \ ; \ \vec{v} = \vec{v}_i + \vec{a}t \]

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: \( f_s \leq \mu_s N \ ; \ f_k = \mu_k N \)

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

\[ E_{total} = K + U_g + U_s \ ; \ \Delta E_{mech} = \Delta K + \Delta U_g + \Delta U_s = -f_i d \ ; \ P = dW / dt = \vec{F} / \vec{v} \ ; \ \Delta K = W \]

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: \( \vec{p} = \text{const and E\# const (inelastic)} \) or \( \vec{p} = \text{const and E= const (elastic)} \)

Rotational motion: \( \omega = 2\pi / T \ ; \ \omega = d\theta / dt \ ; \ \alpha = d\omega / dt \ ; \ v_i = r\omega \ ; \ a_i = r\alpha \)

\( a_c = v_i^2 / r = \omega^2 r \ ; \ a_{rot} = a_i + \alpha i \ ; \ w_{cm} = ro \omega \) (rolling, no slipping); \( a_{cm} = r\alpha \)

\( \omega = \omega_o + at \ ; \ \theta_f = \theta_i + \omega_o t + \alpha t^2 / 2 \ ; \ \omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i) \ ; \ \theta - \theta_i = \frac{\omega_o + \omega_f}{2} t \)

\[ I_{point} = M R^2 \ ; \ I_{hoop} = M R^2 \ ; \ I_{disk} = MR^2 / 2 \ ; \ I_{sphere} = 2MR^2 / 5 \ ; \ I_{shell} = 2MR^2 / 3 \]

\[ I_{rod(center)} = \left( ML^2 / 12 \right) \]

\[ I_{rod(end)} = ML^2 / 3 \ ; \ I = \sum_i m_i r_i^2 \ ; \ I = I_{cm} + Mh^2 \ ; \ \vec{r} = \vec{r} \times \vec{F} \ ; \ \sum_i \tau_i = I\alpha \ ; \ \vec{L} = \vec{r} \times \vec{p} \ ; \ \vec{L} = I\vec{\omega} \]

Energy: \( K = K_{rot} + K_{cm} \ ; \ \Delta K + \Delta U = 0 \ ; \ W = \tau \Delta \theta \ ; \ P_{inst} = \tau \omega \)

Fluid: \( \rho = \frac{M}{V} \ ; \ \rho = \rho \rho g \ ; \ \rho A_1 v_1 = A_2 v_2 \)

\[ P_1 + \rho g y_1 + \frac{1}{2} \rho (v_1)^2 = P_2 + \rho g y_2 + \frac{1}{2} \rho (v_2)^2 \ ; \ B = \rho_{fluid} V^{object} g \]

Gravitation: \( \vec{F}_g = -\frac{Gm_1m_2}{r^2} \hat{r}_{12} \ ; \ g(r) = GM / r^2 \ ; \ U = -GMm_2 / r \ ; \ T^2 = 4\pi^2 a^3 \)

Math: \( 360^\circ = 2\pi \text{ rad} = 1 \text{ rev} ; \ \text{Arc: } s = r\theta \ ; \ V_{sphere} = 4\pi R^3 / 3 \ ; \ A_{sphere} = 4\pi R^2 \ ; \ A_{circle} = \pi R^2 \)

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

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

\[ \vec{C} = \vec{A} + \vec{B} \Rightarrow C_x = A_x + B_x \ ; \ C_y = A_y + B_y \]

\[ \vec{A} \cdot \vec{B} = |\vec{A}||\vec{B}| \cos \theta = A_x B_x + A_y B_y + A_z B_z \ ; \ i \cdot i = j \cdot j = k \cdot k = 1 \ ; \ i \cdot j = i \cdot k = j \cdot k = 0 \]

\[ |\vec{A} \times \vec{B}| = |\vec{A}||\vec{B}| \sin \theta \ ; \ \vec{A} \times \vec{B} = i(A_y B_z - A_z B_y) + j(A_z B_x - A_x B_z) + k(A_x B_y - A_y B_x) \]

\( i \times i = j \times j = k \times k = 0 \ ; \ i \times j = k \ ; \ j \times k = i \ ; \ k \times i = j \)