Physics 106 Common Exam 3: Sample Exam 1 (answers on page 6)

Signature __________________________________

Name (Print): _______________________________       4 Digit ID:________  Section: ______

Instructions:
• Questions 1 through 10 are multiple choice questions worth 5 points each. Answer each of them on the Scantron sheet using #2 pencil. Answer all the questions as there is no penalty for guessing. You will need to do calculations on the exam paper for most of the questions and you may use the back for extra space.
• Questions A and B are workout problems worth 25 points each. Answer them on the exam booklet and show ALL work, otherwise there is no way to give partial credit.
• Be sure your name and section number are on both the Scantron form and the exam booklet. Also write your name, I.d., and section at the top of each page with long answer questions A and B on them.
• You may bring and use your own formula sheet, using both sides of an 8.5 x 11 sheet or two 5x8 cards. A default formula sheet is also provided (see final page of this booklet).
• Make sure to bring your own calculator: sharing of calculators is not permitted.
• As you know, NJIT has a zero-tolerance policy for ethics code violations. Students are not to communicate with each other once the exam has started. All cell phones, pagers, or similar electronic devices should be turned off.
• If you have questions or need something call your proctor or instructor.

1. When determining whether a rigid body is in equilibrium, the vector sum of the gravitational forces acting on the individual particles of the body can **always** be replaced by a single force acting at:
   A) a point on the boundary     B) the geometrical center     C) the center of mass
   D) the center of gravity     E) any of the above

2. A 7- m- long beam of negligible mass is hanged horizontally and is supported at each end by vertical cables. A person of unknown weight is sitting on it somewhere between the cables. The tension in the left cable is 300 N, and that in the right cable is 400 N. How far is the person sitting from the **left** cable?
   A) 3 m     B) 4 m     C) 7 m     D) 6 m     E) 5 m

3. Find the tension $T_2$ in the left hand rope shown in the figure, for the case where $\theta_2 = 60^\circ$, $\theta_3 = 30^\circ$ and $W = mg = 50$ N.
   A) 50 N     B) 100 N     C) 43 N     D) 87 N     E) 29 N

![Diagram of a beam with tensions and angles labeled]
4. A 1000-N block is suspended as shown. The beam AB is weightless and is hinged to the wall at A. The beam is 10 m long. The 4-m-long horizontal cable is attached to the midpoint of the beam AB from a point 3 m above point A on the wall. Find the tension in the horizontal cable,
A) 667 N  B) 2000 N  C) 375 N  D) 2670 N  E) 1000 N

5. A rectangular, uniform chest of drawers 4-feet high and 3-feet wide is standing on a ramp as shown. There is enough friction so that it cannot slide. What is the largest angle θ for which the chest will not topple over?
A) 36.9°  B) 53.1°  C) 41.4°  D) 48.6°  E) Cannot be determined from the information given

6. The magnitude of the acceleration of gravity for a planet in orbit around the Sun is proportional to:
A) the mass of the planet  B) the mass of the Sun  C) the distance between the planet and the Sun  D) the reciprocal of the distance between the planet and the Sun  E) the product of the mass of the planet and the mass of the Sun
7. A starship of mass m is traveling between a pair of binary stars that are a distance R apart. The mass of star 2 is exactly twice the mass of star 1. How far from star 1 will the gravitational force on the starship be equal to zero? Express the answer in terms of R.
A) 1.41R  B) 2R  C) R/0.41  D) R/2  E) R/2.41

8. The acceleration due to gravity on the planet Krypton is 3 times of that on the Earth. The planet's radius is 2 times that of the Earth. What is this planet's mass in terms of the mass of the Earth, $M_e$?
A) 0.75 $M_e$  B) 1.33 $M_e$  C) 12.0 $M_e$  D) 4.0 $M_e$  E) 0.08 $M_e$

9. One of Saturn's moons is in an orbit around Saturn. The moon's mean orbital radius is $1.86 \times 10^8$ m and its period for revolving around Saturn is 22.7 hours. What is the mass of Saturn?
A. $3.75 \times 10^{26}$ kg  B. $2.29 \times 10^{26}$ kg  C. $4.59 \times 10^{26}$ kg  
D. $6.81 \times 10^{26}$ kg  E. $5.69 \times 10^{26}$ kg

10. The Moon takes 27.2 days to revolve around the Earth in an orbit whose radius $R_m$ is about 383,000 km. What would be the approximate orbital radius for an Earth satellite that circles the Earth exactly once per day.
A) 43,000 km  B) 25,000 km  C) 2700 km  D) $3.4 \times 10^6$ km  E) 50,000 km
Show all equations and work for the following problem

Work-out problem A (25 points):

A ladder of mass \( m = 40 \text{ kg} \) and length \( L = 13 \text{ m} \) is leaning against a frictionless wall. Its lower end rests a distance \( a = 6.3 \text{ m} \) from the corner (the pavement is not frictionless). The ladder’s center of mass is \( 2/5 \) \( L \) from the lower end. A firefighter of mass \( M = 68 \text{ kg} \) is located at the center of the ladder.

(a) (1 pt) Determine the height \( h \):

(b) (8 pts.) Sketch all the forces on the ladder and explain separately what they are in a list below. (For example: \( W = \) weight of the ladder, etc....

(c) (4 pts.) Adopt a coordinate system. Then, write down balance of forces equations for the x and y axes (please, clearly indicate the axis in front of each equation):

(d) (5 pts.) Write down the balance of torques with respect to the lower end of the ladder:

(e) (3 pts) Find the reaction force that the wall exerts on the ladder, using your work in part (d):

(f) (4 pts) Determine the reactions from the pavement from part (c) and (e):
Show all equations and work for the following problem:

Work-Out Problem B (25pts):

A spherical asteroid of uniform density has a radius of \( R = 600 \text{ km} \). The gravitational attraction on its surface is \( g = 3.0 \text{ m/s}^2 \).

(a) (4 pts) What is the mass \( M \) of the asteroid?

(b) (4 pts) What is the escape speed \( v \) from the asteroid?

(c) (6 pts) What is the total mechanical energy \( E \) of mass \( m = 1 \text{ kg} \) at the surface of the asteroid as it leaves the asteroid's surface with a radial speed of 1,000 m/s?

(d) (6 pts) How far from the surface will a particle go if it leaves the asteroid with a radial speed of 1,000 m/s as in the previous part?

(e) (5 pts) With what speed will an object hit the asteroid's surface if it is dropped from an altitude of 1,000 km above the surface?
ANSWERS

Multiple Choice:

1. D
2. B
3. C
4. D
5. A
6. B
7. E
8. C
9. E
10. A

Question A:

a) $h = 11.4 \text{ m}$
b) FBD should include $N_{\text{wall}}$, $F_H$ horizontal, $WF$, $WL$, $F_V$ vertical
c) Results for first equilibrium condition are: $N = F_H$ and $F_V = W_L + W_F$
d) Result is: $N_h = W_{Fa}/2 + 2W_La/5$
e) $N = 271 \text{ N}$
f) $F_V = 1058 \text{ N}$, $F_H = N = 271 \text{ N}$

Question B:

a) $M = 1.62 \times 10^{22} \text{ kg}$
b) $V_{\text{esc}} = 1.9 \times 10^3 \text{ m/s}$
c) $E_{\text{mech}} = -1.03 \times 10^6 \text{ Joules}$
d) Maximum altitude = 230 km
e) $v = 1.5 \times 10^3 \text{ m/s}$
PHYSICS 106 FORMULAS

Physics 106:
360 degrees = 2π radians = 1 revolution.  s = rθ  v = rω  a = rα  a_i = a_r = v_i/r = ω^2 r  a_i = ω^2 a_i  ω = ω_0 + αt  θ_i = θ_0 + 1/2αt^2  ω^2 - ω_0^2 = 2α(θ - θ_0)  KE_0 = 1/2l_0^2  I = Σm_i l_i^2  I_{total} = I + m_i l_i^2  l_{inertia} = I_M^2  l_{hypo} = MR^2  l_{disk} = 1/2MR^2  l_{sphere} = 2/5MR^2  l_{shell} = 2/3MR^2  l_{rod (center)} = 1/12ML^2  l_{rod (end)} = 1/3ML^2  τ = F_r sin(θ)  τ_{net} = Στ = I α  F_{net} = ΣF = ma  τ = r x F  \mu = \Sigma \tau m_i sin(θ)  For isolated systems:  τ_{net} = 0  L = constant  ΔL = 0  L_0 = Σl_{i0} = L_fin = Σl_i  Equilibrium:  ΔF = 0  ΔF = 0

Physics 105:
W = mg  g = 9.8 m/s^2  1 m = 100 cm = 1000 mm,  1 kg = 1000 g  v = v_o + at  v = v_m sin(α + φ)  v_m = -ω x_m  a_t = a_m cos(α + φ)  a_m = -ω^2 x_m  x(t) = x_m cos(α + φ)  v(t) = v_m sin(α + φ)  v_m = v_0 + 1/2 at^2  v^2 - v_o^2 = 2a(x - x_o)  x - x_o = 1/2(v + v_0)t  F_{net} = ma  F = dP/dt  F_{net} = ma  F_{s,max} = \mu_k N  F_k = \mu_i N  W_{mg} = mg sin(θ)  W_{mg} = mg cos(θ)  W_{frict} = -F_{frict}  F_{frict} = -m g sin(θ)  W_{frict} = -m g \cdot t  W_{frict} = -F_{frict} \cdot t  W_{frict} = -F_{frict} = -m g \cdot t \cdot cos(θ)
Momentum conserved if net impulse = 0.  Then (Σmv)_{initial} = (Σmv)_{final}

Work:  W = F d(l) = mg(y - y_0)  W_{frict} = -mg(1/2k(x^2 - x_0^2))  W_{frict} = -F_{frict} = -m g \cdot \mu_s \cdot x

Vectors:
Components:  a_x = a \cdot cos(θ)  a_x = a \cdot sin(θ)  a_i = a_{x_i} + a_{y_j}  a = sqrt(a_x^2 + a_y^2)  θ = tan^{-1}(a_y/a_x)
Addition:  a + b = c  implies  c_x = a_x + b_x  c_y = a_y + b_y
Dot product:  a \cdot b = a_x b_x + a_y b_y + a_z b_z  unit vectors:  \hat{i} = \hat{j} = \hat{k} = 1,  \hat{i} = \hat{j} = \hat{k} = 0
Cross product:  |a \times b| = a_b sin(θ)  a \times b = -b \times a  a \times a = 0  c = a \times b  is perpendicular to a-b plane  i \times j = j \times k = k \times i = i \times k = j  etc.