Physics 106 Common Exam 3: Sample Exam 2 (answers on page 5)

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Name (Print): _________________________________   **4 Digit ID:**________ **Section:** ______

Instructions:

1. 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.
2. 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.
3. Be sure your name and section number are on both the Scantron form and the exam booklet. Also write your name, Id., and section at the top of each page with long answer questions A and B on them.
4. 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).
5. Make sure to bring your own calculator: sharing of calculators is not permitted.
6. 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.
7. If you have questions or need something call your proctor or instructor.

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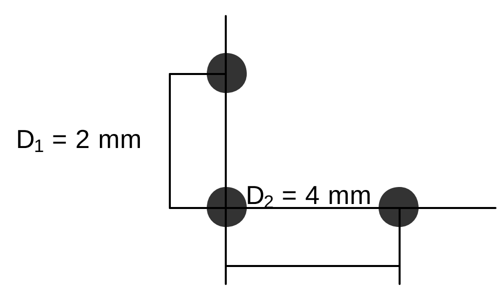
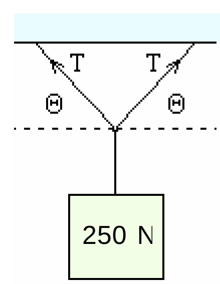
1. Three 20-kg spheres are located in the xy plane as shown. What is the magnitude of the net gravitational force on the sphere at the origin due to the other two spheres?

A. 6.87×10^{-3} N
B. 1.47×10^{-4} N
C. 1.65×10^{-5} N
D. 1.82×10^{-6} N
E. 2.20×10^{-7} N



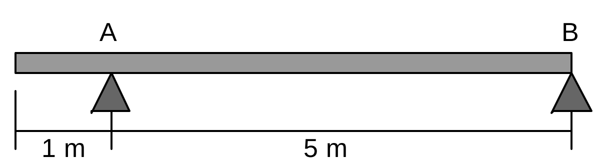
2. Traffic lights weighing 250 N are suspended from a cable as shown. Find the tension T in the string if $\theta_1 = \theta_2 = 35^0$.

A) 120 N   B) 165 N   C) 196 N
D) 218 N   E) 250 N



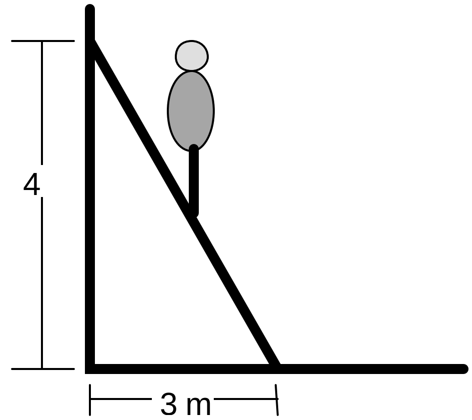
3. 10. A uniform 400-N beam 6 m long rests on two supports, as shown. The force exerted on the beam by the right support B is closest to

A) 50 N   B) 160 N   C) 240 N
D) 320 N   E) 400 N



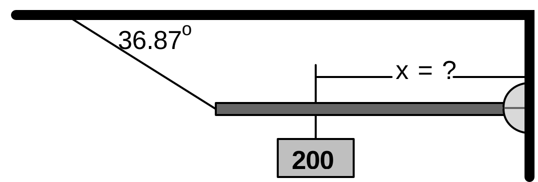
4. A 800-N man stands halfway up a 5 m ladder of negligible weight. The base of the ladder is 3 m from the wall, as shown. Assuming that the wall-ladder contact is frictionless, the wall pushes against the ladder with a force of

A) 100 N B) 200 N C) 300 N
D) 400 N E) 800 N



5. The strut has negligible weight and is 10 m long. How far from the pin must a 200-kg hanging body be attached to produce a 2,000-N tension in the cord?

A) 0.6 m B) 0.8 m C) 5 m
D) 6 m E) 8 m



6. A man weighs 980 N on the surface of the earth ($g = 9.8\ m/s^2$). What is the weight of this man on the surface of Mars? ($M_m = 6.4 \times 10^{23}$ kg, $R_m = 3.395 \times 10^6$ m)

A. 220 N B. 370 N C. 450 N D. 640 N E. 880 N

7. An astronaut in an orbiting spacecraft feels " weightless" because he

A. is beyond the range of gravity
B. is far from the surface of the earth
C. has no acceleration
D. has the same acceleration as the spacecraft
E. is outside the earth's atmosphere

8. A 100 kg projectile is fired straight upward from the earth's surface with a speed of 4000 m/s. If the earth's mass is $M_E = 5.98 \times 10^{24}$ kg and its radius is RE = 6.37×10^6m , the maximum height reached, measured from the center of the earth, is:

A. 9400 km B. 7300 km C. 4800 km D. 3000 km E. 1800 km

9. A planet with the same mass as the earth is in circular orbit around the sun. Its distance from the sun is four times the average distance of the earth from the sun. The period of this planet, in earth years, is

A. 2 years B. 8 years C. 16 years D. 24 years E. 32 years

10. One of Saturn's moons, Mimas, has a mean orbital radius of 1.86×10^8m and a period of 22.7 hours. What is the mass of Saturn?

A. 2.29×10^{26} kg B. 3.75×10^{26} kg C. 4.59×10^{26} kg
D. 5.69×10^{26} kg E. 6.81×10^{26} kg

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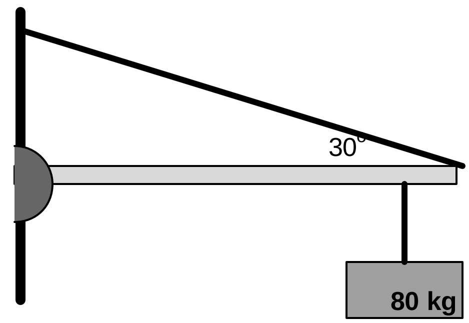
Show all equations and work for the following problem

Work-out problem A (25 points):

A uniform 40-kg beam is pinned at one end and supported at the other end by a cable that makes a 30^0 angle with a horizontal. The beam is 4 m long. An 80 kg load hangs 50 cm from the beam's right end, as shown.



a) Draw the FBD of the beam.

b) Write down the equilibrium equations

c) Find the tension in the cable:

d) . What is the horizontal component of the force exerted on the beam by the pin ?

e) . What is the vertical component of the force exerted on the beam by the pin ?

f) What is the magnitude and direction of the force exerted on the beam by the pin ?

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Show all equations and work for the following problem:

Work-Out Problem B (25pts):

A satellite with a mass of 300 kg moves in a circular orbit 360 km above the earth's surface.

a. What is the gravitational force on the satellite? Ans.____________________________

b. What is the speed of the satellite? Ans.____________________________

c. What is the period of satellite? Ans.____________________________

ANSWERS

Multiple Choice:

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

Question A:

a) FBD should include 4 vertical and 2 horizontal forces
b) Torque equation has three terms, from two weights and T
c) T = 1764 N.
d) F_H = 1528 N
e) F_v = 294 N
f) F = 1555 N

Question B:

a) F = 2640 N.
b) $V_{orb} = 7.7 \times 10^3$ m/s
c) $T = 5.49 \times 10^3$ sec = 91.6 minutes

PHYSICS 106 FORMULAS

Physics 106:

360 degrees = 2π radians = 1 revolution. $s = r\theta$ $v_t = r\omega$ $a_t = r\alpha$ $a_c = a_r = v_t^2/r = \omega^2 r$ $a_{tot}^2 = a_r^2 + a_t^2$

$\omega = \omega_o + \alpha t$ $\theta_f - \theta_o = \omega_o t + ½\alpha t^2$ $\omega_f^2 - \omega_o^2 = 2\alpha(\theta - \theta_o)$ $\theta - \theta_o = ½(\omega + \omega_o)t$ $KE_{rot} = 1/2 I\omega^2$ $I = \Sigma m_i r_i^2$

$I_{point} = mr^2$ $I_{hoop} = MR^2$ $I_{disk} = 1/2\ MR^2$ $I_{sphere} = 2/5\ MR^2$ $I_{shell} = 2/3\ MR^2$ $I_{rod\ (center)} = 1/12\ ML^2$ $I_{rod\ (end)} = 1/3\ ML^2$

τ = force x moment arm = $F\sin(\phi)$ $\tau_{net} = \Sigma\tau = I\alpha$ $\mathbf{F}_{net} = \Sigma\mathbf{F} = m\mathbf{a}$ $\tau = \mathbf{r} \times \mathbf{F}$ $I_p = I_{cm} + Mh^2$

$W_{tot} = \Delta K = K_f - K_I$ $W = \tau_{net}\Delta\theta$ $K = K_{rot} + K_{cm}$ $E_{mech} = K + U$ $P_{average} = \Delta W/\Delta t$

$P_{instantaneous} = \tau.\omega$ (τ constant) $\Delta E_{mech} = 0$ (isolated system) $v_{cm} = \omega r$ (rolling, no slipping)

$\mathbf{l} = \mathbf{r} \times \mathbf{p}$ $\mathbf{p} = m\mathbf{v}$ $\mathbf{L} = \Sigma\, \mathbf{l}_i$ $\tau_{net} = d\mathbf{L}/dt$ $L = I\omega$ $l_{point\ mass} = mrv\sin(\phi)$

For isolated systems: $\tau_{net} = 0$ $\mathbf{L}$ is constant $\Delta\mathbf{L} = 0$ $L_0 = \Sigma I_0\omega_0 = L_f = \Sigma I_f\omega_f$

Equilibrium: Σforces = 0 and Σtorques = 0, If net force on a system is zero, then the net torque is the same for any chosen rotation axis. CG definition: point about which torques due to gravity alone add to zero.

$F = G\frac{m_1 \cdot m_2}{R^2}$; $G = 6.67 \times 10^{-11}$ ($N*m^2/kg^2$); $F_{net} = m\frac{v^2}{R}$; $a_g = G\frac{m}{R^2}$; $E_{mech} = K + U_g$ $K = \frac{1}{2}mv^2$;

$Ug = -G\frac{m_1 \cdot m_2}{R}$; $T^2 = \frac{4\pi^2}{GM}R^3$ $v_{escape} = \sqrt{\frac{2GM}{R}}$; (T^2 / R^3) = const for all satellites of a given body

Angular momentum and mechanical energy are conserved for masses moving under gravitational forces.
$E_{mech} < 0 \rightarrow$ Bound, elliptical orbit.; $E_{mech} > 0 \rightarrow$ Free particle, hyperbolic orbit; $E_{mech} = 0 \rightarrow$ Escape threshold. For circular orbits $F_{centri} = mv^2/r = F_{grav} = GmM/r^2$

Earth: $M_E = 5.98 \times 10^{24}$ kg, $R_E = 6.37 \times 10^6$m, orbital radius about Sun = 1.5×10^8 km
Mars: $M_m = 6.4 \times 10^{23}$ kg, $R_m = 3.395 \times 10^6$ m
Moon: $M_{moon} = 7.36 \times 10^{22}$ kg, $R_{moon} = 1.74 \times 10^6$ m, orbital radius about earth = 3.82×10^5 km

Oscillators in SHM: ω = angular frequency (rad) = $2\pi f = 2\pi/T$. Period $T = 2\pi/\omega$

$x(t) = x_m\cos(\omega t + \phi)$ $v(t) = v_m\sin(\omega t + \phi)$ with $v_m = -\omega x_m$ $a(t) = a_m\cos(\omega t + \phi)$ with $a_m = -\omega^2 x_m$

Oscillator equation: $a(t) = d^2x(t)/dt^2 = -\omega^2 x(t)$

Energy: $E_{osc} = 1/2 mv(t)^2 + 1/2 k\, x(t)^2$ if no damping, then $dE_{osc}/dt = 0$ and E_{osc} is constant
Spring osc: $F = -kx$ $\omega = \mathrm{sqrt}(k/m)$ Torsion pendulum.: $\tau = -\kappa\theta$ $\omega = \mathrm{sqrt}(\kappa / I)$
Pendulums: Simple $\omega = \mathrm{sqrt}(g / L)$ Physical $\omega = \mathrm{sqrt}(mgh / I)$, h = dist to CM from pivot, I = rot. inertia

Physics 105:

$W = mg$ $g = 9.8\ m/s^2$ 1 m = 100 cm = 1000 mm, 1 kg = 1000 g
$v = v_o + at$ $x - x_o = v_o t + ½at^2$ $v^2 - v_o^2 = 2a(x - x_o)$ $x - x_o = ½(v + v_o)t$
$F_{net} = ma$ $\Sigma\mathbf{F} = m\mathbf{a} = d\mathbf{P}/dt$ $F_{s,max} = \mu_s N$ $F_k = \mu_k N$ incline: $W_{mgx} = mg\sin\theta$ $W_{mgy} = mg\cos\theta$
$F_r = ma_r = mv^2/r$ $a_r = v^2/r$ $f = 1/T$ $T = (2\pi r/v)$ Impulse: $F_{avr}\Delta t = mv_f - mv_I$
Momentum conserved if net impulse = 0. Then $(\Sigma mv)_{initial} = (\Sigma mv)_{final}$
Work: $W = Fd(\cos\theta)$, $W_{grav} = -mg(y-y_0)$, $W_{spring} = -1/2k(x^2-x_0^2)$, $W_{frict} = -F_k d$, $W_{tot} = K_f - K_i$
$U_g = mg(y-y_0)$, spring: $F = -kx$, $U_s = 1/2kx^2$, $KE = 1/2mv^2$
$W_{nc} = K_f - K_I + U_{gf} - U_{gi} + U_{sf} - U_{si}$ or $K_I + U_{gi} + U_{si} + W_{nc} = K_f + U_{gf} + U_{sf}$
Mass center: $X_{cm} = \Sigma(x_i m_i)/\Sigma m_i$, similarly for Y_{cm}, Z_{cm}

Vectors:

Components: $a_x = a.\cos(\theta)$ $a_y = a.\sin(\theta)$ $\mathbf{a} = a_x\mathbf{i} + a_y\mathbf{j}$ $a = \mathrm{sqrt}[a_x^2 + a_y^2]$ $\theta = \tan^{-1}(a_y/a_x)$
Addition: $\mathbf{a} + \mathbf{b} = \mathbf{c}$ implies $c_x = a_x + b_x$, $c_y = a_y + b_y$
Dot product: $\mathbf{a}_o\mathbf{b} = a.b.\cos(\phi) = a_x b_x + a_y b_y + a_z b_z$ unit vectors: $\mathbf{i}_o\mathbf{i} = \mathbf{j}_o\mathbf{j} = \mathbf{k}_o\mathbf{k} = 1$, $\mathbf{i}_o\mathbf{j} = \mathbf{i}_o\mathbf{k} = \mathbf{j}_o\mathbf{k} = 0$
Cross product: $|\mathbf{a} \times \mathbf{b}| = a.b.\sin(\phi)$ $\mathbf{a} \times \mathbf{b} = -\mathbf{b} \times \mathbf{a}$, $\mathbf{a} \times \mathbf{a} = \mathbf{0}$ always. $\mathbf{c} = \mathbf{a} \times \mathbf{b}$ is perpendicular to **a-b** plane
$\mathbf{i} \times \mathbf{i} = \mathbf{j} \times \mathbf{j} = \mathbf{k} \times \mathbf{k} = 0$, $\mathbf{i} \times \mathbf{j} = \mathbf{k}$ $\mathbf{j} \times \mathbf{k} = \mathbf{i}$ $\mathbf{k} \times \mathbf{i} = \mathbf{j}$ etc.