Alternative Sitting Answer Key for Test 2

Part A

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

Part B

1	101 rad/s
2	493 N
3	-71.6 J
4	204 J
5	205 N.m

UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

Physics 111.6
<u>MIDTERM TEST #2</u>

November 13, 2003 — Time: 90 minutes

NAME: ______________________________ STUDENT NO.: ____________
(Last) **Please Print** (Given)

LECTURE SECTION (please circle):

01 Dr. A. Robinson
02 B. Zulkoskey
03 Dr. A. Manson
C15 F. Dean

<u>INSTRUCTIONS:</u>

1. You should have a test paper, a formula sheet, and an OMR sheet. The test paper consists of 9 pages. **It is the responsibility of the student to check that the test paper is complete.**
2. Enter your name and <u>STUDENT NUMBER</u> on the OMR sheet.
3. The test paper, the formula sheet and the OMR sheet must all be submitted.
4. The test paper will be returned. The formula sheet and the OMR sheet will <u>NOT</u> be returned.

PLEASE DO NOT WRITE ANYTHING ON THIS TABLE

QUESTION NO.	MAXIMUM MARKS	MARKS OBTAINED
Part A	10	
Part B	10	
C1	5	
C2	5	
C3	5	
TOTAL	35	

continued on page 2 ...

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PART A

FOR EACH OF THE FOLLOWING QUESTIONS IN PART A, ENTER THE MOST APPROPRIATE RESPONSE ON THE OMR SHEET.

$\frac{mv_1^2}{r} = \frac{m(2v_1)^2}{r_2} \Rightarrow r_2 = 4r$

A1. A car travelling in uniform circular motion is on the verge of sliding as it goes around a flat curve of radius r. If the car's speed is now doubled, what is the smallest radius of flat curve that the car can negotiate without sliding? Assume that the coefficient of static friction between the tires and road surface is the same for both curves.

E

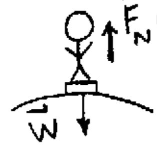
(A) ¼ r (B) ½ r (C) r (D) 2 r (E) 4 r

$f_s^{MAX} = F_{cent}$ is constant

A2. Your true weight has been recently established by a measurement made at the North Pole. Now imagine that you are standing on the same scale at the equator. Because of the rotation of the spherical Earth,

A

(A) the scale reading is slightly less than your true weight.
(B) the scale reading is slightly more than your true weight.
(C) the scale reading is the same as your true weight.
(D) the scale reading is zero.
(E) the scale reading fluctuates between zero and your true weight with a period of 12 h.



$W - F_N = F_{cent}$ ∴ $F_N < W$

A3. Which one of the following statements concerning a satellite in a circular orbit around the Earth is **<u>false</u>**?

D

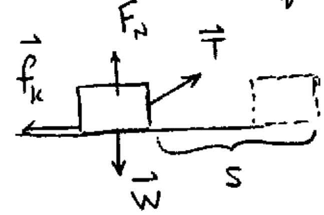
(A) For a particular orbit radius there is one and only one value for the speed of the satellite.
(B) The satellite is kept in its circular orbit by the gravitational force of the Earth.
(C) The speed of the satellite is inversely proportional to the square root of the radius of the orbit.
(D) The speed of the satellite depends on the mass of the satellite.
(E) The speed of the satellite depends on the mass of the Earth.

$\frac{GM_E m}{r^2} = \frac{mv^2}{r}$ → $v = \sqrt{\frac{GM_E}{r}}$

A4. A rope is used to drag a crate at <u>constant velocity</u> over a rough horizontal floor. Which one of the following statements is **<u>false</u>**? ↳ $\Delta KE = 0 \Rightarrow W_{net} = 0$

E

(A) The work done by the normal force on the crate is zero.
(B) The work done by the gravitational force on the crate is zero.
(C) The work done by the frictional force on the crate is negative.
(D) The work done by the tension force on the crate is positive.
(E) The net work done on the crate is greater than zero.



A5. Which one of the following statements is **<u>false</u>**?

C

(A) The SI unit of gravitational potential energy is the Joule.
(B) Gravitational potential energy is measured with respect to an arbitrary zero level.
(C) The work done by the gravitational force depends on the path taken between initial and final heights.
(D) Gravitational potential energy is a scalar quantity.
(E) The work done by the gravitational force is the difference between initial and final gravitational potential energies.

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A6. Which one of the following statements is **false**?

(A) Total mechanical energy is conserved if the net work done by non-conservative forces is zero.

B (E)* Total mechanical energy is the sum of the kinetic energy and the gravitational potential energy.

(C) Gravity is a conservative force.

(D) A force is non-conservative if the work it does on an object moving between two points depends on the path between the two points.

(B)* Friction is a conservative force. $W_{friction}$ depends directly on length of path.

A7. While floating initially at rest in a space station, a girl of mass M pushes a boy of mass $2M$. As a result of the push, the boy moves away with a speed v and the girl

E

(A) remains at rest.

(B) moves in the same direction as the boy with a speed v.

(C) moves in the same direction as the boy with a speed $2v$.

(D) moves in the opposite direction as the boy with a speed v.

(E) moves in the opposite direction as the boy with a speed $2v$.

Cons. of Linear Momentum

$\vec{P}_{tot_f} = \vec{P}_{tot_0}$

$Mv_g + (2M)v = 0$

$v_g = -2v$

A8. Which one of the following statements is correct?

D

(A) An object with a negative angular acceleration must be rotating clockwise.

(B) An object with a constant angular acceleration is undergoing uniform circular motion.

(C) An object with a constant angular acceleration has a constant tangential velocity.

(D) An object with a constant angular acceleration can have a zero value for the instantaneous tangential velocity. e.g. a wheel momentarily stops before reversing dir'n of rotation

(E) An object with a negative angular acceleration must have an angular velocity of decreasing magnitude.

A9. Which one of the following statements concerning the moment of inertia I is **false**?

B

(A) I may be expressed in units of kg·m^2.

(B) I depends on the angular acceleration of the object as it rotates. $I = \sum m_i r_i^2$

(C) I depends on the location of the rotation axis relative to the particles that comprise the object.

(D) I depends on the orientation of the rotation axis relative to the particles that comprise the object.

(E) Of the particles that comprise the object, the particle with the smallest mass may contribute the greatest amount to I.

A10. A spinning star begins to collapse under its own gravitational pull (so $\sum \tau_{ext} = 0$). Which one of the following occurs as the star becomes smaller?

D

(A) Its angular velocity decreases.

(B) Its angular momentum increases.

(C) Its angular velocity remains constant.

(D) Its angular momentum remains constant.

(E) Both its angular momentum and its angular velocity remain constant.

Cons. of Ang. Momentum:

$L_0 = L_f$ if $\sum \tau_{ext} = 0$

$I_0 \omega_0 = I_f \omega_f$

$I_f < I_0$ (collapses)

so $\omega_f > \omega_0$.

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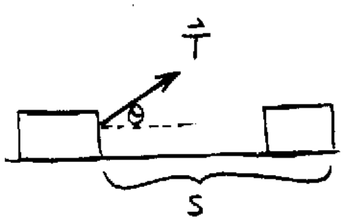
PART B

FOR EACH OF THE FOLLOWING PROBLEMS, WORK OUT THE SOLUTION IN THE SPACE PROVIDED AND ENTER YOUR ANSWERS ON PAGE 6.

ONLY THE ANSWERS WILL BE MARKED. THE SOLUTIONS WILL NOT BE MARKED.

B1. A rope is used to drag a crate across the floor. Given that the rope makes an angle of 30.0° with the floor and that the tension in the rope is 45.0 N, calculate the work done on the crate by the tension in the rope when the crate is dragged a distance of 6.00 m.

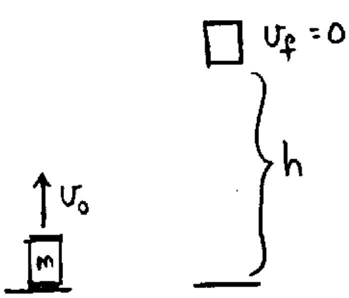


$$W = (F\cos\theta)s$$

$$W = (45.0\,\text{N} \cos 30.0^\circ)(6.00\,\text{m})$$

$$W = 234\ \text{J}$$

B2. A projectile of mass 1.00 kg is shot vertically into the air with an initial speed of 20.0 m/s. If the projectile rises to a height of 19.3 m, calculate the work done by air resistance.



$$E_0 + W_{nc} = E_f$$

$$W_{nc} = E_f - E_0$$

$$W_{nc} = mgh - \frac{1}{2}mv_0^2$$

$$W_{nc} = 1.00\,\text{kg}\left((9.80\,\text{m/s}^2)(19.3\,\text{m}) - \frac{1}{2}(20.0\,\text{m/s})^2\right)$$

$$W_{nc} = -10.9\ \text{J}$$

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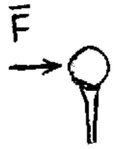
B3. Mike Weir drives a golf ball from the tee with a velocity of 40.0 m/s. The mass of the golf ball is 0.0450 kg and the duration of the impact with the golf club is 3.50×10^{-3} s. Determine the (magnitude of the) average force applied to the ball by the club.



$v_0 = 0, \; v_f = 40.0\,m/s$

Impulse - Momentum Theorem

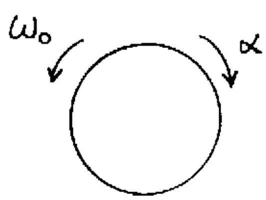
$$\vec{F}\Delta t = \Delta\vec{p}$$

$$|\vec{F}| = \frac{|\Delta\vec{p}|}{\Delta t} = \frac{|mv_f - mv_0|}{\Delta t}$$

$$= \frac{|(0.0450\,kg)(40.0\,m/s)|}{3.50\times10^{-3}\,s}$$

$$= 514\,N$$

B4. A wheel, originally rotating at 125 rad/s, undergoes a constant angular deceleration of 5.00 rad/s^2. Calculate the angular velocity of the wheel after it has turned through an angle of 628 radians.



$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

$$\omega = \left[(125\,rad/s)^2 + 2(-5.00\,rad/s^2)(628\,rad)\right]^{1/2}$$

$$\omega = 96.7\,rad/s$$

continued on page 6 ...

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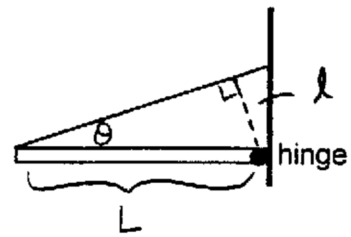
B5. A rod of length 1.50 m is attached to a vertical wall by a frictionless hinge. The rod is held horizontal by a cable attached to the end of the rod and to the wall. The cable makes an angle of 25.0° with the rod and the tension in the cable is 342 N. Calculate the magnitude of the torque exerted on the rod by the cable.



$\tau = F\ell$

$\tau = FL\sin\theta = (342\,N)(1.50\,m)\sin 25.0°$

$\tau = 217\,N\cdot m$

ANSWERS FOR PART B

ENTER THE ANSWERS FOR THE PART B PROBLEMS IN THE BOXES BELOW.

THE ANSWERS MUST BE EXPRESSED TO **THREE SIGNIFICANT FIGURES AND THE UNITS MUST BE GIVEN.**

ONLY THE ANSWERS WILL BE MARKED. THE SOLUTIONS WILL NOT BE MARKED.

B1	234 J
B2	− 10.9 J
B3	514 N
B4	96.7 rad/s
B5	217 N·m

continued on page 7 ...

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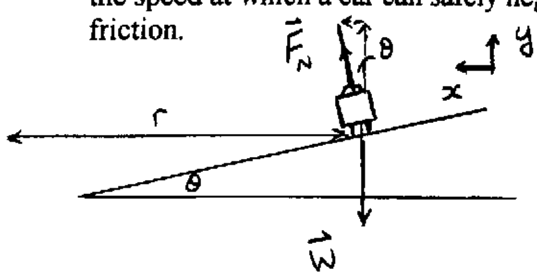
PART C

IN EACH OF THE FOLLOWING QUESTIONS, GIVE THE COMPLETE SOLUTION AND ENTER THE FINAL ANSWER IN THE BOX PROVIDED.

THE ANSWERS MUST ^BE EXPRESSED TO **THREE SIGNIFICANT FIGURES AND THE UNITS MUST BE GIVEN.**

SHOW YOUR WORK - NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY. EQUATIONS NOT PROVIDED ON THE FORMULA SHEET MUST BE DERIVED.

C1. A highway curve of radius 425 m is banked at an angle of 12.5° with the horizontal. Calculate the speed at which a car can safely negotiate this curve without sliding, in the absence of friction.



30.4 m/s

$\sum F_x = ma_c$

$F_N \sin\theta = \frac{mv^2}{r}$

$\left(\frac{mg}{\cos\theta}\right)\sin\theta = \frac{mv^2}{r}$

$\sum F_y = 0$

$F_N \cos\theta - W = 0$

$F_N \cos\theta = W$

$F_N \cos\theta = mg$

$F_N = \frac{mg}{\cos\theta}$

$v = \sqrt{rg\tan\theta}$

$v = \left[(425\,m)(9.80\,m/s^2)(\tan 12.5°)\right]^{1/2}$

$v = 30.4\,m/s$

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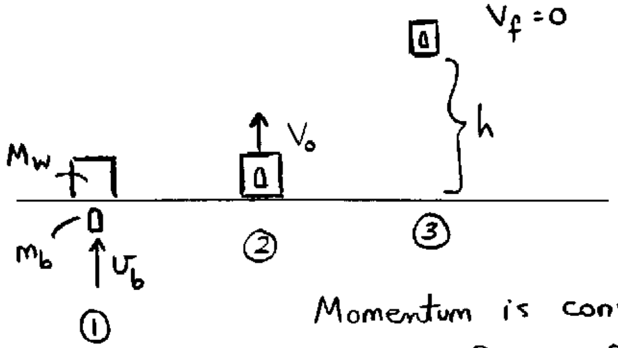
C2. To measure the muzzle speed of a gun, the gun is placed against a block of wood of mass M_w and a bullet of mass m_b is fired vertically upward into the block. The bullet embeds itself in the block, and the block (with embedded bullet) is blasted straight up into the air to a height h. Ignore any frictional effects and assume that the bullet-block collision is over before the block has started to move upward.

Derive an expression for the speed of the bullet as it left the gun barrel, in terms of M_w, m_b, h, and g, the acceleration due to gravity.



$$\frac{(M_b + M_w)}{m_b} \cdot \sqrt{2gh}$$

Momentum is conserved in the bullet-block collision:

$$P_{tot_1} = P_{tot_2}$$

$$m_b v_b + M_w \cdot 0 = (m_b + M_w) V_o$$

$$v_b = \frac{(m_b + M_w) V_o}{m_b}$$

Need to determine an expression for V_o, use cons. of mech energy b/w ② and ③:

$$E_2 = E_3$$

$$\frac{1}{2}(m_b + M_w) V_o^2 = (m_b + M_w) g h$$

$$V_o^2 = 2gh$$

$$V_o = \sqrt{2gh}$$

$$\therefore \quad v_b = \left(\frac{m_b + M_w}{m_b}\right) \sqrt{2gh}$$

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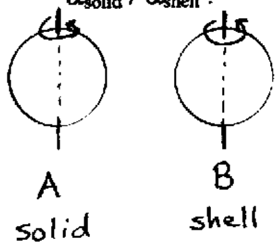
C3. Two spheres with ~~identical~~ constant mass and radius are each rotating about an axis passing through the sphere's centre. The spheres have the same initial angular velocity, and are suddenly subjected to the same net external torque which eventually brings the two spheres to rest. One sphere is solid and the other is a thin-walled spherical shell.

(a) While the torque is acting on the spheres, the solid sphere has an angular acceleration of α_{solid} and the spherical shell has an angular acceleration of α_{shell}. Calculate the ratio $\alpha_{solid} / \alpha_{shell}$.



$M_A = M_B = M$; $\omega_{0A} = \omega_{0B} = \omega_0$

$R_A = R_B = R$; $\tau_{ext_A} = \tau_{ext_B} = \tau_{ext}$

$I_A = \frac{2}{5} MR^2$; $I_B = \frac{2}{3} MR^2$

5/3

From Newton II for Rotation:

$$\tau_{ext} = I\alpha$$

A: $\tau_{ext} = \frac{2}{5} MR^2 \alpha_A$

B: $\tau_{ext} = \frac{2}{3} MR^2 \alpha_B$

$$\therefore \frac{\alpha_{solid}}{\alpha_{shell}} = \frac{\alpha_A}{\alpha_B} = \frac{\frac{5}{2}\frac{\tau_{ext}}{MR^2}}{\frac{3}{2}\frac{\tau_{ext}}{MR^2}}$$

$$\frac{\alpha_{solid}}{\alpha_{shell}} = \frac{5}{3}$$

(b) If the time taken for the solid sphere to stop rotating is t_{solid} and the time taken for the spherical shell to stop rotating is t_{shell}, calculate the ratio t_{solid} / t_{shell}.

3/5

From rotational kinematics,

$$\omega = \omega_0 + \alpha t$$

and since $\omega = 0$, $t = -\frac{\omega_0}{\alpha}$

$$\therefore \frac{t_A}{t_B} = \frac{-\omega_0/\alpha_A}{-\omega_0/\alpha_B} = \frac{\alpha_B}{\alpha_A}$$

$$\frac{t_{solid}}{t_{shell}} = \frac{\alpha_{shell}}{\alpha_{solid}} = \frac{3}{5}$$

END OF EXAMINATION