Physics 111 Test 2 – Alternative Sitting Answers

A1	C	B1	6.93 s
A2	E		
A3	D	B2	20.5 m/s
A4	B		
A5	A	B3	3.78×10^3 N
A6	C		
A7	A	B4	97.4 rad/s
A8	E		
A9	D	B5	17.6 N·m
A10	B		

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PART A

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

A1. A car travels around a curve of radius r with a speed v_1 and experiences a centripetal acceleration a_{c1}. The car then travels around a second curve of the same radius as the first but experiences a centripetal acceleration a_{c2} that has twice the magnitude of a_{c1}. The speed of the car around the second curve is

B

(A) v_1 (B) $\sqrt{2}\,v_1$ (C) $\frac{v_1}{\sqrt{2}}$ (D) $2\sqrt{2}\,v_1$ (E) $2v_1$

$a_{c_2} = 2a_{c_1}$

$\frac{v_2^2}{r} = 2\left(\frac{v_1^2}{r}\right)$

$v_2^2 = 2v_1^2$

$v_2 = \sqrt{2}\,v_1$

A2. Which one of the following forces is conservative?

D

(A) air resistance (B) static friction (C) kinetic friction
(D) gravitational force (E) normal force

A3. Which one of the following statements is ***FALSE***?

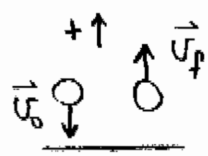
B

(A) The work done by a conservative force on an object is independent of the path between the object's initial and final positions. T
(B) A force is conservative if the work done in moving an object around a closed path, starting and finishing at the same point, is non-zero. F
(C) A force is non-conservative if the work done on an object moving between two points depends on the path taken between the two points. T
(D) Both conservative and non-conservative forces may act simultaneously on an object. T
(E) The net work done on an object by non-conservative forces is equal to the change in ~~gravitational~~ potential energy plus the change in kinetic energy. T

A4. A ball of mass m is dropped from a height h. The speed of the ball just before it hits the ground is v_o and the speed of the ball just after rebounding from the floor is v_f. The magnitude of the impulse exerted by the floor on the ball is

A

(A) $m(v_o + v_f)$ (B) $m(v_o - v_f)$ (C) $mgh(v_o + v_f)$
(D) $mgh(v_o - v_f)$ (E) $m(v_o + v_f)/h$



Impulse $= \Delta\vec{p}$

$|\Delta\vec{p}| = |mv_f - m(-v_o)|$

$= m(v_f + v_o)$

A5. An object of mass m moving with a velocity v collides with a stationary object of mass M. If the two objects stick together, what is their velocity after the collision?

B

(A) $\frac{M}{(m+M)}v$ (B) $\frac{m}{(m+M)}v$ (C) $\frac{(m+M)}{m}v$ (D) $\frac{(m+M)}{M}v$ (E) 0

$\vec{p}_f = \vec{p}_o$

$(m+M)v_f = mv$

$v_f = \frac{m}{(m+M)}v$

A6. Two children are standing on a rotating platform. Child A is twice as far from the axis of rotation as child B. Given that ω represents angular velocity and v represents tangential velocity, which one of the following statements is correct?

E

(A) $\omega_A > \omega_B$ (B) $\omega_A < \omega_B$ (C) $v_A = v_B$ (D) $v_A < v_B$ (E) $v_A > v_B$

$\omega_A = \omega_B$

$v_A = r_A\omega_A$; $v_B = r_B\omega_B$; $r_A = 2r_B$

$\therefore v_A = 2r_B\omega_A = 2r_B\omega_B = 2v_B$

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A7. Two particles with different masses are observed to have the same non-zero momentum. Which one of the following statements **must** be true?

E

(A) The particles must have the same kinetic energy.
(B) The total momentum of the system of two particles must be zero.
(C) The particles must have the same speed.
(D) The particles must be at rest.
(E) The particles must be travelling in the same direction.

$\vec{p} = m\vec{v}$

Since m's are different so are v's
Since $\vec{p}$ is a vector, the v's must have the same dir'n

A8. Four of the following statements apply to an object in equilibrium. Which statement is **not** a condition for equilibrium?

C

(A) The sum of the externally applied torques is zero. ✓
(B) The object has zero translational acceleration. ✓
(C) The object has zero translational velocity.
(D) The sum of the externally applied forces is zero. ✓
(E) The object has zero angular acceleration. ✓

A9. Which one of the following statements is ***FALSE***?

B

(A) The SI unit for moment of inertia is $kg.m^2$. T
(B) The moment of inertia of a body is equal to its mass. F
(C) The moment of inertia of a body is dependent on the location of the rotation axis relative to the particles which make up the body. T
(D) The moment of inertia is the ratio of the net torque acting on a rigid body to the angular acceleration (in rad/s^2) produced by the torque. T
(E) The total moment of inertia of a rigid body can be obtained by summing the moments of inertia of the individual components of that body. T

A10. How should the mass of a rotating body be distributed so as to maximize its angular acceleration for a given applied torque?

C

(A) The mass should be concentrated at the outer edge of the body.
(B) The mass should be evenly distributed throughout the body.
(C) The mass should be concentrated near the axis of rotation.
(D) The mass should be concentrated at a point midway between the axis of rotation and the outer edge of the body.
(E) Mass distribution has no impact on angular acceleration.

$$\sum \tau = I\alpha$$

$$\alpha = \frac{\sum \tau}{I}$$

and I depends on distance of mass from axis of rotation. The greater the distance, the larger the value of I, (and the smaller the value of α).

continued on page 4...

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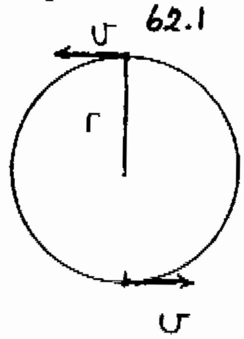
PART B

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. Calculate the time required to travel halfway around a circular track of radius 126 m at a constant speed of ~~60.0~~ 62.1 m/s.



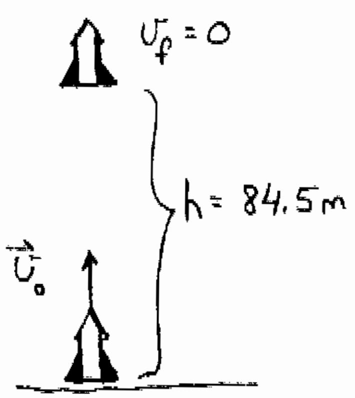
$$v = \frac{2\pi r}{T} \Rightarrow T = \frac{2\pi r}{v}$$

for this problem, $t = \frac{1}{2}T$

$$t = \frac{1}{2}T = \frac{1}{2}\left(\frac{2\pi r}{v}\right) = \frac{\pi r}{v}$$

$$t = \frac{\pi\,(126\,m)}{62.1\,m/s} = 6.37\,s$$

B2. A firework rocket of mass 0.125 kg is launched and rises to a maximum altitude of 84.5 m, where it has a speed of 0 m/s. The work done by non-conservative forces during the flight to this point is 82.9 J. Calculate the initial launch speed.



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

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

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

$$v_0^2 = 2gh - \frac{2W_{nc}}{m}$$

$$v_0 = \left[2\left(gh - \frac{W_{nc}}{m}\right)\right]^{1/2}$$

$$v_0 = \left[2\left(9.80\,m/s^2 \cdot 84.5\,m - \frac{82.9\,J}{0.125\,kg}\right)\right]^{1/2}$$

$$v_0 = 18.2\,m/s$$

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0.145 95.6 0.00425

B3. A bat strikes a ~~0.0525~~-kg ball so that the ball's velocity changes by ~~26.8~~ m/s in ~~0.115~~ s. Calculate the magnitude of the average force with which the bat struck the ball.

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

$$|\vec{F}| = \left|\frac{\Delta\vec{p}}{\Delta t}\right| = \frac{m|\Delta\vec{v}|}{\Delta t} = \frac{(0.145\,\text{kg})(95.6\,\text{m/s})}{0.00425\,\text{s}}$$

$$|\vec{F}| = 3.26\times10^{3}\,\text{N}$$

B4. A ceiling fan undergoes an angular acceleration of ~~magnitude of~~ − 43.7 rad/s^2 as its angular velocity decreases from its initial value to a final value of (+ 66.9 rad/s in a time of 2.61 s. Calculate the initial angular velocity of the fan.

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

$$\omega_0 = \omega - \alpha t$$

$$\omega_0 = +66.9\,\text{rad/s} - (-43.7\,\text{rad/s}^2)(2.61\,\text{s})$$

$$\omega_0 = 181\,\text{rad/s}$$

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B5. You open a door by exerting a force of 45.1 N at an angle of 20.7° to the surface normal and at a point 0.750 m from the door hinge. Calculate the torque applied to the door.

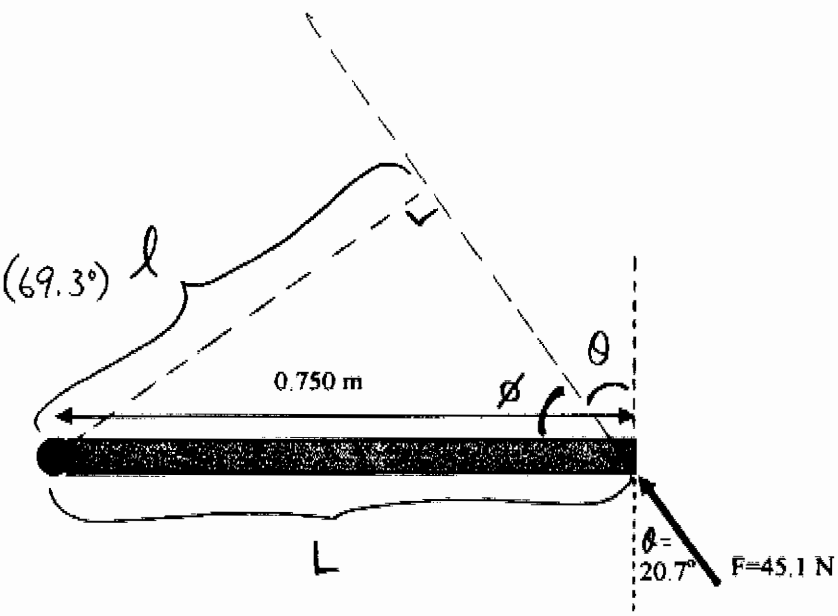
$\tau = F\ell$

$\tau = F(L\sin\phi)$

$\tau = FL\sin(90° - \theta)$

$\tau = (45.1\,N)(0.750\,m)\sin(69.3°)$

$\tau = 31.6\,N\cdot m$



ANSWERS FOR PART B

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

THE ANSWERS MUST CONTAIN THREE SIGNIFICANT FIGURES AND THE UNITS MUST BE GIVEN.

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

B1	6.37 s
B2	18.2 m/s
B3	3.26×10^3 N
B4	181 rad/s
B5	31.6 N·m

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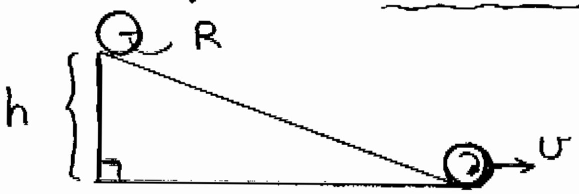
PART C

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

THE ANSWERS MUST CONTAIN THREE SIGNIFICANT FIGURES AND THE UNITS MUST BE GIVEN.

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

C1. A uniform solid disk of radius 0.343 m, starting from rest at a height 2.56 m above the ground, rolls without slipping down a ramp. Calculate the speed of the disk at the bottom of the ramp. You may assume that no non-conservative forces do work on the disk.



so $E_f = E_o$

$\boxed{5.78\ m/s}$

$$KE_{trans_f} + KE_{rot_f} + PE_f = K_{trans_o} + KE_{rot_o} + PE_o$$

$$\frac{1}{2}mv_f^2 + \frac{1}{2}I\omega_f^2 + 0 = 0 + 0 + mgh$$

rolling w/o slipping $\Rightarrow v_f = R\omega_f \Rightarrow \omega_f = \frac{v_f}{R}$

uniform solid disk $\Rightarrow I = \frac{1}{2}mR^2$

$$\therefore \frac{1}{2}\cancel{m}v_f^2 + \frac{1}{2}\left(\frac{1}{2}\cancel{m}R^2\right)\left(\frac{v_f}{R}\right)^2 = \cancel{m}gh$$

$$\frac{1}{2}v_f^2 + \frac{1}{4}v_f^2 = gh$$

$$\frac{3}{4}v_f^2 = gh$$

$$v_f = \sqrt{\frac{4gh}{3}} = \sqrt{\frac{4(9.80\,m/s^2)(2.56\,m)}{3}}$$

$$v_f = 5.78\,m/s$$

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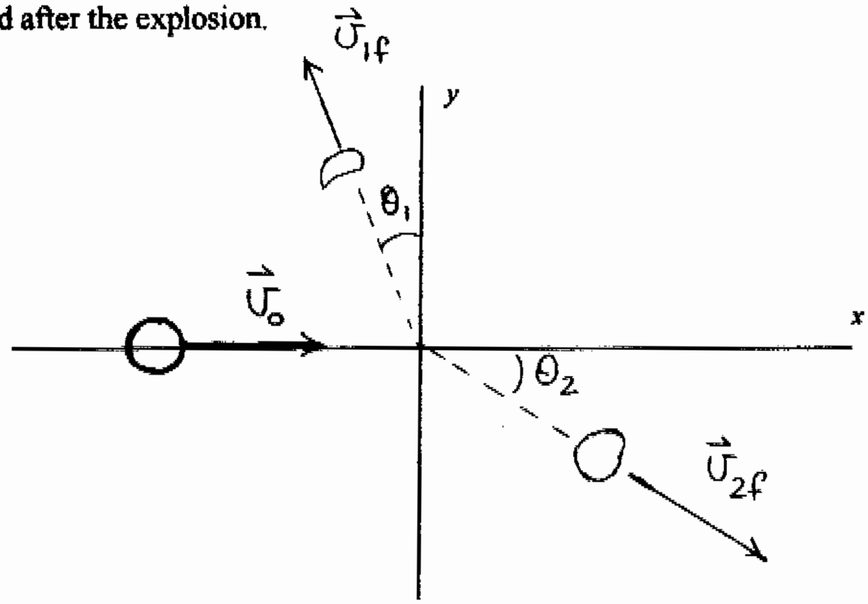
C2. A curling rock of mass M is sliding along the ice in the $+x$ direction with speed v_o when it mysteriously explodes into two pieces. The pieces remain in contact with the ice surface.

After the explosion, one piece with mass 0.270 M moves at a speed of v_{1f} = 7.35 m/s at an angle of 10.5° counterclockwise from the positive y axis. The second piece, which has a mass of 0.730 M, moves at a speed of v_{2f} = 4.25 m/s at an angle of 39.0° clockwise from the positive x axis.

(a) On the given coordinate system, sketch the velocities of the curling rock and its pieces before and after the explosion.



(b) Calculate the speed of the curling rock before the explosion. The ice surface is horizontal and frictionless.

$$\boxed{2.05\ \text{m/s}}$$

$$\Sigma \vec{F}_{ext} = 0 \quad \text{so} \quad \vec{P}_{tot_f} = \vec{P}_{tot_o}$$

$$\therefore \quad P_{tot_{f_x}} = P_{tot_{o_x}} \qquad \text{and} \qquad P_{tot_{f_y}} = P_{tot_{o_y}}$$

$$m_1 v_{1f_x} + m_2 v_{2f_x} = M v_o \qquad\qquad m_1 v_{1f_y} + m_2 v_{2f_y} = 0$$

$$-0.270 \cancel{M} v_{1f} \sin\theta_1 + 0.730 \cancel{M} v_{2f} \cos\theta_2 = \cancel{M} v_o$$

$$(-0.270)(7.35\ \text{m/s})(\sin 10.5°) + (0.730)(4.25\ \text{m/s})(\cos 39.0°) = v_o$$

$$v_o = 2.05\ \text{m/s}$$

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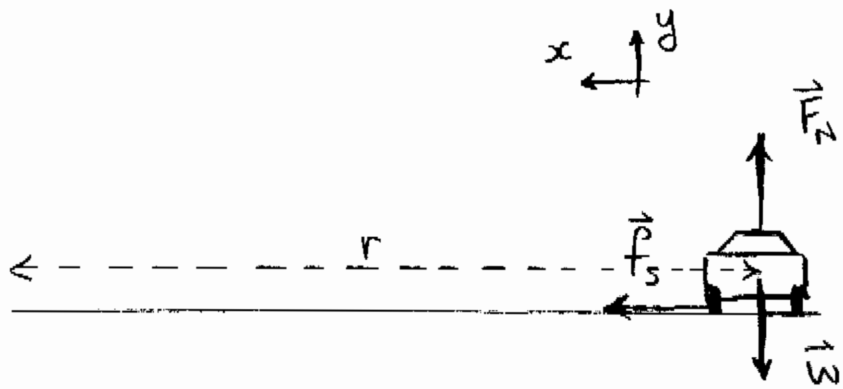
C3. A car is travelling around an unbanked curve of radius r (friction is present). Let v_{max} represent the maximum speed at which the car can negotiate the curve without sliding.

(a) Draw a well-labelled free body diagram of the forces acting on the car.



(b) Derive an expression for the coefficient of static friction, μ_s, between the tires and the road surface in terms of v_{max}, r, and g.

When the car is travelling at v_{max} (on the verge of sliding), $f_s = f_s^{MAX}$.

$$\boxed{\mu_s = \frac{v_{max}^2}{rg}}$$

$$\sum \vec{F} = m\vec{a}$$

$$\sum F_x = ma_c$$

$$f_s^{MAX} = m\left(\frac{v_{max}^2}{r}\right)$$

$$\mu_s F_N = \frac{m v_{max}^2}{r}$$

$$\mu_s = \frac{m v_{max}^2}{r F_N}$$

from $\sum F_y = 0$, $F_N - W = 0$

$$F_N = W$$

$$F_N = mg$$

$$\mu_s = \frac{\cancel{m} v_{max}^2}{r \cancel{m} g}$$

$$\mu_s = \frac{v_{max}^2}{rg}$$

(c) If the curve has a radius of 53.2 m and the car has a speed of $v_{max} = 37.0$ km/h, calculate the coefficient of static friction.

$$\mu_s = \frac{v_{max}^2}{rg} = \frac{\left(37.0\,\mathrm{km/h} \times \frac{1000\,\mathrm{m}}{\mathrm{km}} \times \frac{1\,\mathrm{h}}{3600\,\mathrm{s}}\right)^2}{(53.2\,\mathrm{m})(9.80\,\mathrm{m/s^2})}$$

$$\boxed{0.203}$$

$$\mu_s = 0.203$$

END OF EXAMINATION