UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

Physics 115.3 – Physics and the Universe

<u>FINAL EXAMINATION</u>

December 13, 2014   Time: 3 hours

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

LECTURE SECTION (please check):

          ❑   01   Dr. M. Bradley

          ❑   02   Dr. R. Pywell

          ❑   03   B. Zulkoskey

          ❑   97   Dr. A. Farahani

          ❑   C15 Dr. A. Farahani

<u>INSTRUCTIONS:</u>

1. This is a closed book examination.

2. The test package includes a test paper (this document), a formula sheet, and an OMR sheet. The test paper consists of 11 pages, including this cover page. **It is the responsibility of the student to check that the test paper is complete**.

3. Only a basic scientific calculator (e.g. Texas Instruments TI-30X series, Hewlett-Packard HP 10s or 30S) may be used. Graphing or programmable calculators, or calculators with communication capability, are **<u>not</u>** allowed.

4. Enter your name and student number on the cover of the test paper and check the appropriate box for your lecture section. Also enter your student number in the top right-hand corner of each page of the test paper.

5. Enter your name and NSID on the OMR sheet.

6. The test paper, the formula sheet and the OMR sheet must all be submitted.

7. None of the test materials will be returned.

ONLY THE <u>FIVE</u> PART B QUESTIONS THAT <u>YOU INDICATE</u> WILL BE MARKED

PLEASE <u>INDICATE</u> WHICH <u>FIVE</u> PART B QUESTIONS ARE TO BE MARKED

| QUESTION NUMBER	TO BE MARKED	MAXIMUM MARKS	MARKS OBTAINED
A1-25	☑	25	
B1	❑	10	
B2	❑	10	
B3	❑	10	
B4	❑	10	
B5	❑	10	
B6	❑	10	
TOTAL		75	

PART A

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

A1. If an object's velocity and acceleration are both zero at an instant in time, which one of the following statements best describes the motion of the object?

- (A) The object is at a turning point in its motion.
- (B) The object's velocity will increase at a later time.
- (C) The object's velocity will decrease at a later time.
- (D) The object is in free fall.
- (E) The object is stationary (at rest).

A2. A child standing on a bridge throws a rock straight down. The rock leaves the child's hand with a speed of v_0 at time $t = 0$. Which one of the following velocity versus time graphs best represents the velocity of the rock as a function of time? (Up is the positive direction.)
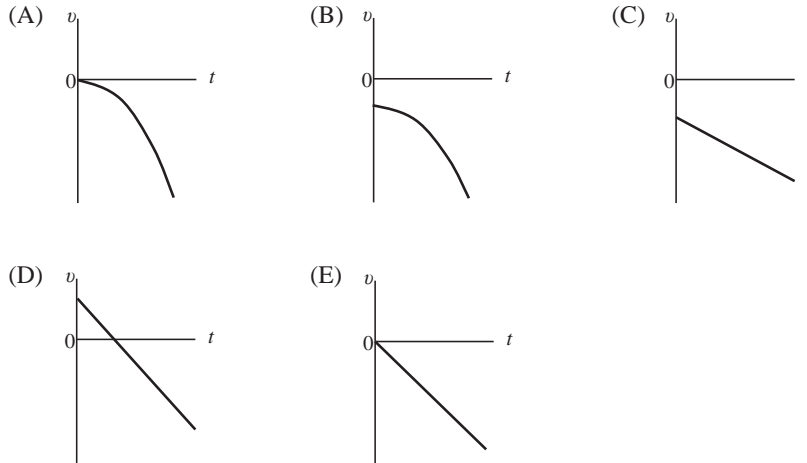
A3. A ballast bag of sand is dropped from a hot air balloon when it is at rest at a height h above the ground and it takes a time t for the bag to reach the ground. Later, when the hot air balloon is again at rest, a second bag is dropped and it takes a time $4t$ to reach the ground. What was the height of the balloon when the second bag was dropped? (Air resistance may be ignored.)

(A) $2h$ (B) $4h$ (C) $8h$ (D) $16h$ (E) $64h$

A4. In the following equations, the variables x and y are distances, the variables v_0 and v are speeds, the variable t is a time, and the variable a is an acceleration. Which one of the equations is **NOT** <u>dimensionally</u> correct?
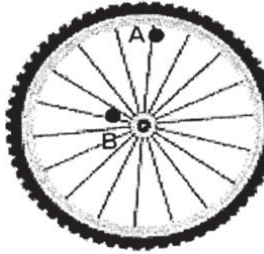
(A) $v = \frac{1}{2}at + \frac{x}{t}$ (B) $y = \frac{1}{2}a\frac{x^2}{v^2}$ (C) $\frac{x}{t} = \frac{1}{2}v_0$ (D) $a = \frac{2y}{t^2}$ (E) $\frac{x}{t^2} = \frac{1}{2}v^2$

A5. An object travelling with an initial speed v_0 is brought to rest in a distance d by a net force with a magnitude of F. If the initial speed of the object is doubled to $2v_0$, what is the magnitude of the net force, in terms of F, that is necessary to bring the object to rest in the same distance d.
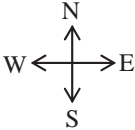
(A) F (B) $2F$ (C) $3F$ (D) $4F$ (E) $8F$

A6. Imagine you are launching a ball vertically into the air with a spring-loaded gun. If you wanted to double the ball's maximum height above the gun, what could you do?

- (A) Decrease the spring's compression to ¼ of the initial compression distance.
- (B) Decrease the spring's compression to $\frac{1}{\sqrt{2}}$ of the initial compression distance.
- (C) Increase the spring's compression to $\sqrt{2}$ times the initial compression distance.
- (D) Increase the spring's compression to 2 times the initial compression distance.
- (E) Increase the spring's compression to 4 times the initial compression distance.

A7. A crate remains stationary after it has been placed on a ramp inclined at an angle with the horizontal. Which one of the following statements must be true regarding the magnitude of the frictional force that acts on the crate?

   (A) The magnitude of the frictional force is greater than the magnitude of the weight of the crate.
   (B) The magnitude of the frictional force is greater than or equal to the weight of the crate.
   (C) The magnitude of the frictional force is equal to zero.
   (D) The magnitude of the frictional force is greater than the component of the gravitational force acting down the ramp.
   (E) The magnitude of the frictional force is equal to the component of the gravitational force acting down the ramp.

A8. The kinetic energy of a rocket is increased by a factor of 8 after its engines are fired, whereas its total mass is reduced by half through the burning of the fuel. By what factor is the magnitude of its momentum changed?

   (A) The momentum is changed by a factor of 2.
   (B) The momentum is changed by a factor of 4.
   (C) The momentum is changed by a factor of 8.
   (D) The momentum is changed by a factor of 16.
   (E) The momentum is unchanged.

A9. Consider a car that is travelling at constant speed around a curve of constant radius. Which one of the following statements is correct concerning the net force on the car?

   (A) The net force on the car is directed radially inward – toward the centre of the curve.
   (B) The net force on the car is directed radially outward – away from the centre of the curve.
   (C) The net force on the car is zero.
   (D) The net force on the car is tangent to its path.
   (E) The net force on the car is directed vertically upward.

A10. A satellite is moving in a stable, circular orbit around the Earth. Which one of the following statements is **FALSE**?

   (A) The speed of the satellite depends on the mass of the satellite.
   (B) The speed of the satellite depends on the mass of the Earth.
   (C) The speed of the satellite depends on the radius of the orbit.
   (D) The speed of the satellite depends on the universal gravitational constant.
   (E) The speed of the satellite depends on the acceleration due to gravity at its location.

A11. An object at the end of a string is swung in a circular path at constant speed with a period T. If the period is shortened to $\frac{1}{2}T$ without changing the radius of the circle, what is the new centripetal acceleration in terms of the original centripetal acceleration a_c?

   (A) $4a_c$ (B) $2a_c$ (C) a_c (D) $\frac{1}{2}a_c$ (E) $\frac{1}{4}a_c$

A12. What can be said about the angular (ω) and linear (υ) velocities at the two marked points (A and B) on the rotating bicycle wheel shown in the figure to the right?

   (A) $\omega_A > \omega_B$ and $\upsilon_A > \upsilon_B$.
   (B) $\omega_A < \omega_B$ and $\upsilon_A < \upsilon_B$.
   (C) $\omega_A = \omega_B$ and $\upsilon_A > \upsilon_B$.
   (D) $\omega_A = \omega_B$ and $\upsilon_A < \upsilon_B$.
   (E) $\omega_A = \omega_B$ and $\upsilon_A = \upsilon_B$.

A13. Suppose that a wheel experiences an angular acceleration α_1 when it is acted upon by a net torque τ. If the net torque acting on the wheel is doubled, how will the new angular acceleration, α_2, compare to α_1?

   (A) $\alpha_2 = \frac{1}{4}\alpha_1$ (B) $\alpha_2 = \frac{1}{2}\alpha_1$ (C) $\alpha_2 = \alpha_1$ (D) $\alpha_2 = 2\alpha_1$ (E) $\alpha_2 = 4\alpha_1$

A14. A hoop, a solid disk, and a solid sphere are rolling without slipping along a flat surface. The objects have equal masses and equal radii and they are rolling with equal speeds. Which one of the following statements is correct concerning their total kinetic energies?

(A) $KE_{\text{hoop}} = KE_{\text{disk}} = KE_{\text{sphere}}$ (B) $KE_{\text{hoop}} = KE_{\text{disk}} < KE_{\text{sphere}}$ (C) $KE_{\text{hoop}} < KE_{\text{disk}} < KE_{\text{sphere}}$
(D) $KE_{\text{hoop}} = KE_{\text{disk}} > KE_{\text{sphere}}$ (E) $KE_{\text{hoop}} > KE_{\text{disk}} > KE_{\text{sphere}}$

A15. A figure skater, initially spinning with arms and one leg outstretched, pulls her arms and leg in so that they are close to her body. Which one of the following statements correctly describes what happens when she pulls her arms and leg toward her body?

(A) Her angular momentum increases and she spins faster.
(B) Her angular momentum decreases and she spins faster.
(C) Her moment of inertia increases and she spins faster.
(D) Her moment of inertia decreases and she spins faster.
(E) Her moment of inertia remains constant and she spins faster.

A16. Two forces are acting on an object. Which one of the following statements is correct?

(A) The object is in equilibrium if the forces are equal in magnitude and opposite in direction.
(B) The object is in equilibrium if the net torque on the object is zero.
(C) The object is in equilibrium if the forces act at the same point on the object.
(D) The object is in equilibrium if the net force and the net torque on the object are both zero.
(E) The object cannot be in equilibrium because more than one force acts on it.

A17. The magnitude of the electric field due to a point charge at a distance of 4.0 m away from that charge is measured to be 100 N/C. The magnitude of the electric field at a distance of 2.0 m away from the charge is…

(A) 400 N/C.   (B) 200 N/C.   (C) 100 N/C.   (D) 50 N/C.   (E) 25 N/C.

A18. A metal sphere is grounded (connected to the Earth) through a closed switch. A positively charged balloon is brought near to, but not touching, the metal sphere and then the switch is opened. After the charged balloon is taken away what is the charge on the metal sphere?

(A) It is zero.
(B) It is positive.
(C) It is negative.
(D) It may be positive or negative depending on the magnitude of the charge on the balloon.
(E) It will be positive at the point nearest to where the balloon was, but zero on the other side.

A19. Consider two identical positive charges. Which one of the following statements is correct concerning the electric field and the absolute electric potential at the point located midway along the line between the two charges?

(A) Both the electric field and the absolute electric potential are zero.
(B) The electric field points toward the rightmost charge and the absolute electric potential is zero.
(C) The electric field points toward the leftmost charge and the absolute electric potential is zero.
(D) The electric field is perpendicular to the line between the two charges and the absolute electric potential is zero.
(E) The electric field is zero and the absolute electric potential is not zero.

A20. Consider two conducting spheres. The spheres are identical except that Sphere 1 initially has a charge of $q_{1i} = +4$ μC and Sphere 2 initially has a charge of $q_{2i} = -2$ μC. The conducting spheres are brought into contact and then separated. The charges on the spheres are now…

(A) $q_{1f} = +4$ μC and $q_{2f} = +2$ μC.   (B) $q_{1f} = +3$ μC and $q_{2f} = -3$ μC.
(C) $q_{1f} = +1$ μC and $q_{2f} = +1$ μC.   (D) $q_{1f} = +2$ μC and $q_{2f} = 0$ μC.
(E) $q_{1f} = 0$ μC and $q_{2f} = +2$ μC.

A21. A metal wire of resistance R is cut into 3 equal pieces that are then placed side by side to form a new cable with length equal to 1/3 the original length. What is the resistance of this new cable?

(A) $\frac{1}{9}R$ (B) $\frac{1}{3}R$ (C) R (D) $3R$ (E) $9R$

A22. Two light bulbs are connected in series, one operating at 120 W and one operating at 60.0 W. If the voltage drop across the series combination is 120 V, what is the current in the circuit?

(A) 1.0 A   (B) 1.5 A   (C) 2.0 A   (D) 2.5 A   (E) 3.0 A

A23. The lamps in a string of holiday decoration lights are connected in parallel. The lights are powered by a constant voltage emf. What happens when one lamp burns out (becomes open circuit)? Assume negligible resistance in the wires leading to the lamps.

(A) The brightness of the other lamps does not change.
(B) The other lamps get brighter equally.
(C) The other lamps get dimmer equally.
(D) The other lamps get brighter, but some get brighter than others.
(E) All the lamps go out.

A24. A power of 100 W is delivered to a wire when an emf of 10 V is connected across it. The wire is then replaced with another which is made from the same material and has the same length, but has a diameter that is twice that of the first. If we want the same power of 100 W to be delivered to the second wire, what emf must be connected across it?

(A) 1.4 V   (B) 2.5 V   (C) 5 V   (D) 20 V   (E) 40 V

A25. In a region where the Earth's magnetic field points toward the North, a wire carries a current vertically downward (toward the ground). In which direction is the magnetic force on the wire?

(A) Toward the North.
(B) Toward the South.
(C) Toward the East.
(D) Toward the West.
(E) The force is zero.

PART B

ANSWER FIVE OF THE PART B QUESTIONS ON THE FOLLOWING PAGES AND INDICATE YOUR CHOICES ON THE COVER PAGE.

FOR EACH OF YOUR CHOSEN PART B QUESTIONS ON THE FOLLOWING PAGES, GIVE THE COMPLETE SOLUTION AND ENTER THE FINAL ANSWERS IN THE BOXES PROVIDED.

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

SHOW AND EXPLAIN YOUR WORK – NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY.

EQUATIONS NOT PROVIDED ON THE FORMULAE SHEET MUST BE DERIVED.

USE THE BACK OF THE PREVIOUS PAGE FOR YOUR ROUGH WORK.

B1. A cannon is fired at a wall that is a horizontal distance of 295 m from the cannon. It takes 4.45 s
for the cannon ball to hit the wall.
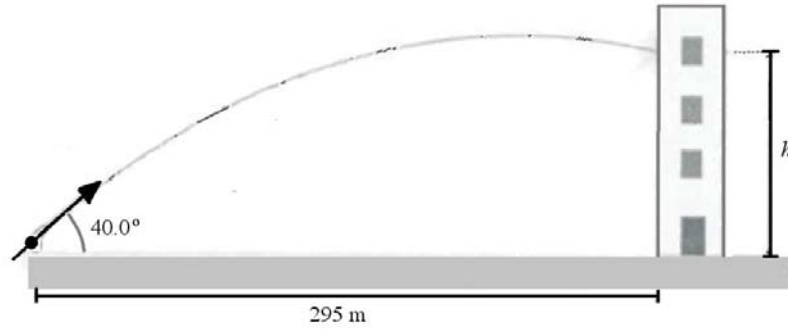
(a) Calculate the initial speed of the cannon ball. (*3 marks*)

(b) At what height above the level ground does the cannon ball hit the wall? If you did not obtain
an answer for (a), use a value of 90.0 m/s. (*3 marks*)

(c) Calculate the speed of the cannon ball just before impact with the wall. If you did not obtain
an answer for (b), use a value of 1.60×10^2 m. (*4 marks*)

B2. The figure to the right shows two blocks, A and B, connected by
a massless rope. The rope passes over a massless, frictionless
pulley. There is friction between the surface and block A. The
coefficient of static friction between the surface and block A is
0.300 and the coefficient of kinetic friction between the surface
and block A is 0.150. The entire system is in static equilibrium.
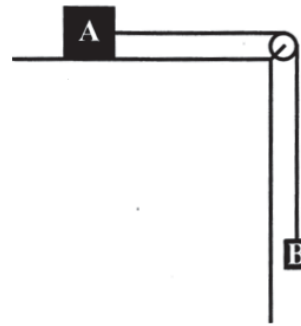
(a) What kind of friction is opposing the tension force applied
by the rope on block A (circle your choice): (*2 marks*)

   STATIC FRICTION   **KINETIC FRICTION**

(b) Draw the free body diagrams for blocks A and B. (*3 marks*)

(c) Suppose block A has a mass of 5.00 kg. Calculate the maximum mass of block B under the
condition that static equilibrium is just maintained. That is, if the mass of B was any greater
than this value, the blocks would move. (*5 marks*)

B3. A car, starting from rest, travels a distance of one-quarter of a mile (402 m) in a time of 12.8 s. Each wheel of the car has a mass of 18.2 kg and a radius of 30.5 cm.

(a) Assuming constant acceleration, calculate the magnitude of the acceleration of the car. (*3 marks*)

(b) Assuming that the car's wheels roll without slipping, calculate the magnitude of the angular velocity of the wheels at a time of 12.8 s after the car started moving. If you did not obtain an answer for (a), use a value of 5.00 m/s^2. (*3 marks*)

(c) Calculate the net torque exerted on each wheel of the car while it is accelerating. You may approximate each wheel as a uniform solid cylinder. If you did not obtain an answer for (a), use a value of 5.00 m/s^2. (*4 marks*)

B4. The mass of the Earth is 5.98×10^{24} kg, the radius of the Earth is 6.37×10^{6} m, and the mean radius of the Earth's orbit about the sun is 1.50×10^{11} m.

   (a) Calculate the angular momentum of the Earth that arises due to the fact that the Earth spins about its axis with a period of 24.0 h. You may treat the Earth as a uniform solid sphere. (*6 marks*)

   (b) Calculate the angular momentum of the Earth that arises from its orbital motion about the sun. You may treat the Earth as a point particle. (*4 marks*)

B5. A potential difference of 956 V is applied across two parallel plates that are separated by a distance of 2.50 cm. The electric field between the plates is uniform.
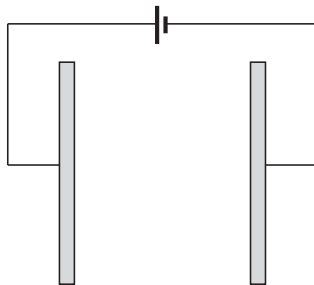
(a) Calculate the magnitude of the electric field between the plates. (*3 marks*)

(b) A proton is released from rest at the plate with the higher potential. Calculate the kinetic energy of the proton when it has travelled a distance of 1.25 cm after being released. Express your answer in eV (electron volts). (*4 marks*)

(c) Calculate the speed of the proton just before it reaches the other plate. The mass of the proton is 1.67×10^{-27} kg. (*3 marks*)

B6. A light bulb labelled "100.0 W @ 117 V" is connected to its power plug via a long extension cord in which each conductor has a resistance of 1.00 Ω. For testing purposes, the extension cord is plugged into a 105 V DC supply.

(a) Calculate the resistance of the light bulb. (*3 marks*)

(b) Draw a circuit diagram of the test circuit configuration described in the statement of the problem. (*3 marks*)

(c) Calculate the actual power dissipated by the light bulb in the test circuit. If you did not obtain an answer for (a), use a value of 135 Ω. (*4 marks*)

END OF EXAMINATION