UNIVERSITY OF SASKATCHEWAN
Department of Physics and Engineering Physics

Physics 111.6 General Physics

<u>FINAL EXAMINATION</u>

April 16, 2008   Time: 3 hours

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

LECTURE SECTION (please check):

       ❑   01   Dr. A. Robinson

       ❑   02   B. Zulkoskey

       ❑   03   D. Loughran

       ❑   97   M. Lepage

       ❑ 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 10 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. None of the test materials will be returned.

5. This is a closed book examination.

6. Only Hewlett-Packard HP 30S or Texas Instruments TI-30X series calculators may be used.

PLEASE DO NOT WRITE ANYTHING ON THIS TABLE

| QUESTION NUMBER	MAXIMUM MARKS	MARKS OBTAINED
A1-20	20	
B1-10	20	
C1	10	
C2	10	
C3	10	
TOTAL	70	

PART A

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

A1.   Which one of the following is **NOT** a unit of energy?

(A) W   (B) N·m   (C) J   (D) eV   (E) kg·m^2/s^2

A2.   Which one of the following is a vector quantity?

(A) electric charge   (B) time   (C) work

(D) electric field   (E) electric potential

A3.   When a force is described as "conservative", what is it that is being conserved?

(A) Linear Momentum   (B) Force   (C) Kinetic Energy

(D) Potential Energy   (E) The sum of Kinetic Energy and Potential Energy

A4.   Two objects, one of mass m and the other of mass $2m$, are dropped from the top of the same building. When they hit the ground

(A)   both will have the same kinetic energy.
(B)   the heavier one will have twice the kinetic energy of the lighter one.
(C)   the heavier one will have four times the kinetic energy of the lighter one.
(D)   the heavier one will have one-half the kinetic energy of the lighter one.
(E)   the heavier one will have one-fourth the kinetic energy of the lighter one.

A5.   An artificial Earth satellite is moved from a stable circular orbit of radius R to a stable circular orbit of radius $2R$. During this move,

(A)   the gravitational force of the Earth on the satellite does positive work and the kinetic energy of the satellite increases.
(B)   the gravitational force of the Earth on the satellite does positive work and the kinetic energy of the satellite decreases.
(C)   the gravitational force of the Earth on the satellite does negative work and the kinetic energy of the satellite decreases.
(D)   the gravitational force of the Earth on the satellite does negative work and the kinetic energy of the satellite increases.
(E)   the gravitational force of the Earth on the satellite does negative work and the kinetic energy of the satellite does not change.

A6.   For an ideal spring, which one of the following statements is **TRUE**?

(A)   The magnitude of the restoring force is inversely proportional to the magnitude of the displacement from the unstretched length.
(B)   The elastic potential energy of the spring cannot be zero.
(C)   The restoring force acts in the direction opposite to that of the displacement from the unstretched length.
(D)   The elastic potential energy of the spring is negative when the displacement is negative.
(E)   The elastic potential energy of the spring is a maximum when the displacement from the unstretched position is zero.

A7.   A hoop and a solid cylinder have the same mass, the same radius, and both roll along a horizontal surface without slipping. If the rotational kinetic energies of the two objects are the same, then which one of the following statements is **TRUE**?

(A)   The translational velocity of the solid cylinder is greater than the translational velocity of the hoop.
(B)   The translational velocity of the hoop is greater than the translational velocity of the solid cylinder.
(C)   The translational velocities of the two objects are equal.
(D)   The angular velocity of the hoop is greater than the angular velocity of the solid cylinder.
(E)   The moments of inertia of the two objects are equal.

A8. A torque τ is applied to a bolt by exerting a force **F** at the end of a wrench of length L. The direction of the force is perpendicular to the length of the wrench, as shown in the diagram. The torque is not sufficient to turn the bolt, so a new wrench of length $3L$ is used and a force of $2F$ is applied at its end. The direction of the force is the same as before. The new torque exerted on the bolt is

(A) 9τ (B) 4τ (C) 5τ (D) 6τ (E) 1.5τ
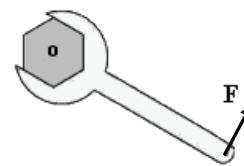
A9. Which one of the following statements best describes the principle of operation of a hydraulic jack?

(A) A small change of pressure in the small cylinder results in a large change of pressure in the large cylinder.
(B) A large change of pressure in the small cylinder results in a small change of pressure in the large cylinder.
(C) The same change of pressure occurs throughout the system, resulting in a large force on the large piston.
(D) A small amount of work done on the small piston results in a large amount of work done on the large piston.
(E) The force exerted on the small piston equals the force acting on the large piston.

A10. The sound intensity at a certain distance from a constant-power source is I. Assuming the sound radiates uniformly in all directions, what would be the sound intensity if the listener were twice as far away from the source?

(A) $\frac{1}{4}I$ (B) $\frac{1}{2}I$ (C) $2I$ (D) $4I$ (E) $8I$

A11. The fundamental frequency of an organ pipe that is initially open at both ends is related to its length. When a cap is placed over one end of the organ pipe (making one end closed), the fundamental frequency will

(A) double.   (B) increase by 25%.   (C) be halved.

(D) not change.   (E) become one-quarter of its original value.

A12. A metal ball initially has a net charge of $2Q$. This ball is brought into contact with an identical, but initially uncharged, metal ball. The two metal balls are separated and the first ball is brought into contact with a third identical, but initially uncharged, ball. The resulting charge on the third metal ball is

(A) $\frac{1}{3}Q$ (B) $\frac{2}{3}Q$ (C) $\frac{1}{2}Q$ (D) $\frac{3}{2}Q$ (E) Q

A13. Consider the electrostatic force exerted between two positive point charges. Which one of the following statements is **FALSE**?

(A) The magnitude of the force is inversely proportional to the square of the distance between the two charges.
(B) The force is repulsive.
(C) The force is proportional to the magnitude of each of the charges.
(D) The force is proportional to the sum of the two charges.
(E) The direction of the force is along the line joining the two point charges.

A14. The law of reflection states that the angle of reflection equals the angle of incidence. The angle of incidence is defined as

(A) the angle between the incident ray and the surface of the reflecting object.
(B) the angle between the incident ray and the reflected ray.
(C) the angle between the incident ray and the normal drawn at the point where this ray meets the reflecting surface.
(D) the angle between the reflected ray and the surface of the reflecting object.
(E) equal to half the angle between the reflected ray and the surface of the reflecting object.

A15. For the human eye, which one of the following statements is **FALSE**?

(A)   Nearsightedness (myopia) can be corrected using a diverging lens.
(B)   The near point of the eye is the minimum distance at which an object is still in focus.
(C)   The far point of the eye is the maximum distance at which an object is still in focus.
(D)   The focal length of the eye cannot be changed.
(E)   The far point of a person with perfect vision is infinity.

A16. Photons with an energy of 6 eV cause electrons to be emitted from the surface of an unknown metal with a maximum kinetic energy of 4 eV. If photons having twice the wavelength are incident on the same metal surface, which one of the following statements is **TRUE**?

(A)   No electrons will be emitted.
(B)   Electrons will be emitted with a maximum kinetic energy of 1 eV.
(C)   Electrons will be emitted with a maximum kinetic energy of 5 eV.
(D)   Electrons will be emitted with a maximum kinetic energy of 8 eV.
(E)   Electrons will be emitted with a maximum kinetic energy of 10 eV.

A17. If visible light passes from one transparent medium to another transparent medium that has a different refractive index, which one of the following statements is **FALSE**?

(A)   The wavelength of the light changes.
(B)   The frequency of the light changes.
(C)   The direction in which the light travels changes.
(D)   The speed with which the light travels changes.
(E)   Both the wavelength and the speed with which the light travels change.

A18. Choose the phrase that correctly completes the following sentence: The results of the Rutherford scattering experiment provide evidence that

(A)   electrons in an atom can have only certain energies.
(B)   electromagnetic radiation can exhibit particle characteristics when interacting with electrons in a material.
(C)   the positive charge of an atom is contained in a small region (the nucleus).
(D)   light of sufficiently high frequency can cause electrons to be emitted from a metal surface.
(E)   the energy of a photon is determined by its frequency.

A19. The ratio of the radius of the nucleus of ^{238}U to that of the nucleus of ^{12}C is given by:

(A) $\dfrac{238}{12}$ (B) $\left(\dfrac{238}{12}\right)^{1/2}$ (C) $\sqrt{\dfrac{238}{12}}$

(D) $\left(\dfrac{238}{12}\right)^{1/3}$ (E) $(1.2 \times 10^{-15}\text{ m})\left(\dfrac{238}{12}\right)^{2}$

A20. Which one of the following statements is **FALSE**?

(A)   The strong nuclear force is exerted by both protons and neutrons.
(B)   Stable nuclei of low Z usually have the same number of protons as neutrons.
(C)   The strong nuclear force has a very short range of about 2×10^{-15} m.
(D)   Stable nuclei of high Z have more protons than neutrons.
(E)   The strong nuclear force is an attractive force.

PART B

**FOR EACH OF THE FOLLOWING PROBLEMS, B1 TO B10, ON PAGES 5, 6 AND 7, WORK OUT THE
SOLUTION IN THE SPACE PROVIDED AND ENTER YOUR ANSWERS ON PAGE 7.
ONLY THE ANSWERS WILL BE MARKED. THE SOLUTIONS WILL NOT BE MARKED.**

B1. A 725-kg elevator accelerates downward at 3.12 m/s^2. Calculate the magnitude of the tension
exerted by the elevator cable.

B2. A vehicle moves in a horizontal circle of radius 122 m with constant speed. The vehicle has a
mass of 2.53×10^3 kg, and the coefficient of static friction between the road and the vehicle's tires
is 0.451. Calculate the maximum speed at which the vehicle can negotiate the turn without
skidding.

B3. A beach ball, with a mass of 0.124 kg, is held stationary and fully submerged in water by pushing
down on it with a force of 7.00 N. Calculate the buoyant force on the beach ball when it is fully
submerged.

B4. The reel of a fishing rod has a radius of 3.00 cm (assumed constant). A fisherman winds 2.60 m of fishing line onto the reel in a time of 9.50 s. Assuming that the line is being reeled in at a constant speed, calculate the angular velocity of the reel.

B5. A steel cable of cross-sectional area 2.83×10^{-3} m^2 has a tension of 1.12×10^4 N. The density of steel is 7.86×10^3 kg/m^3. Calculate the speed of a transverse wave moving along the cable.

B6. An ideal battery with an emf of 12.0 volts is connected across two resistors in parallel. The resistors have values of 96.0 Ω and 552 Ω. Calculate the current flowing through the 96.0 Ω resistor.

B7. At its closest approach to Earth, the comet 1999/S4 was a distance of 5.44×10^{10} m from the Earth. Calculate the time required for light from the comet to reach Earth.

B8. Calculate the angle of refraction for light moving from acetone (refractive index of 1.36) to water (refractive index of 1.33), given that the angle of incidence is 29.8°.

B9. Violet light of wavelength of 412 nm illuminates a diffraction grating that has 2.65×10^3 lines/cm. Calculate the angle of the second-order maximum.

B10. A sample initially contains 5.40 g of radioactive material that has a half-life of 8.00 days. Calculate the mass of radioactive material remaining after 4.00 days.

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 [   ]   **B6** [   ]

B2 [   ]   **B7** [   ]

B3 [   ]   **B8** [   ]

B4 [   ]   **B9** [   ]

B5 [   ]   **B10** [   ]

PART C

IN EACH OF THE PART C QUESTIONS ON THE FOLLOWING PAGES, 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. 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.

C1. A source produces monoenergetic photons, each of which has an energy of 4.65×10^3 eV.

(a) Calculate the wavelength of one of the photons.

(b) The photons are incident on a graphite target and undergo Compton scattering. Calculate the wavelength of the photons that scatter at an angle of 135° relative to the incident direction. (If you did not obtain answer for (a) use a value of 2.61×10^{-10} m.)

(c) The source produces an average power of 12.5 W. Calculate the number of photons produced per second.

C2. A spring-loaded gun is to used to shoot a ball to knock a tomato off a post. The ball has a mass of 0.0450 kg and a speed of 6.70 m/s when it leaves the end of the gun. The tomato has a mass of 0.227 kg and is at a height of 1.36 m above the end of the gun and a horizontal distance of 2.25 m from the end of the gun.
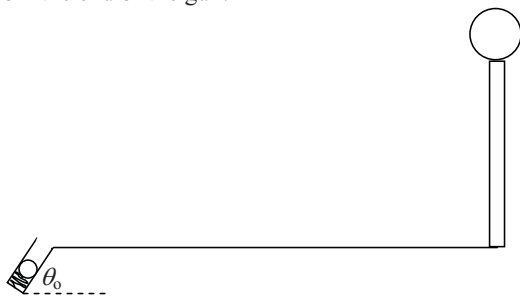
(a) Calculate the angle θ_o at which the gun must be inclined so that the ball is moving horizontally when it hits the tomato.

(b) The spring is uncompressed when the ball is at the opening of the gun barrel. The gun is fired by compressing the spring, placing the ball on the compressed spring, and then releasing the spring. The spring must be compressed a distance of 0.0752 m so that the ball has a speed of 6.70 m/s when it leaves the end of the gun. Calculate the spring constant.

(c) The ball has a completely inelastic collision with the tomato. Calculate the speed of the combined tomato/ball immediately after the collision. You may ignore the effects of any external forces that may be acting during the collision.

C3. A box of mass 46.5 kg slides up a ramp that is inclined at an angle of 37.0° above the horizontal. The initial velocity of the box is 5.25 m/s and the coefficient of kinetic friction between the box and the ramp is 0.270.

(a) On the following diagram, draw the forces acting on the box when it is moving up the ramp. Also show your choice of coordinate system.
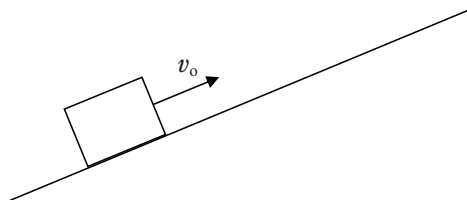
(b) Calculate the distance that the box travels along the ramp before momentarily coming to rest.

(c) After coming to rest for an instant, the box slides down the ramp. Calculate the speed of the box when it returns to its initial position on the ramp.

(d) Calculate the work done on the box by the kinetic frictional force as the box moves from its initial position, up the ramp, and then back down the ramp to its initial position.

END OF EXAMINATION