RYERSON UNIVERSITY
DEPARTMENT OF PHYSICS
PCS 125 FALL 2008 FINAL-TERM EXAMINATION

DURATION: 150 minutes **DATE: December 8, 2008**

Student Number	Section	PRINT first name	PRINT family name

Circle your instructor's name.

Beauchemin **Ford** **Hu** **Toronov** **Yuan**

INSTRUCTIONS

• This is a closed ‐ book exam; pens, pencils, erasers, calculators and your Ryerson ID are the only allowed items on your desk. Your Ryerson photo ID must be on your desk at all times.

• The only calculators allowed are the Sharp EL ‐ 546 and Casio FX ‐ 991**.**

• **PDAs**, **phones, and pagers must be turned off** and **out of reach.** Coats, jackets, caps, food, drinks and bags must be placed out of reach.

• The examination consists of 27 equally weighted multiple choice questions.

• We may check your work, and if your answer is not justified by it, credit will not be given. You may use the back of the pages for rough work.

• Select the option that is numerically closest to your answer, circle it in this booklet and then copy it to the bubble sheet carefully using a pencil.

• **Only the bubble sheet will be marked.**

• If more than one choice is presented for a question (on either the test sheet or the bubble sheet), you may not get any credit for that question.

- **Read each question carefully, and make sure you understand it before attempting to answer it.**

Please sign here indicating you have read and understood the above instructions.

Signature: ____

(no signature can result it no mark!)

DO NOT OPEN THE EXAM UNTIL YOU ARE TOLD TO DO SO.

Then, before you start writing, verify that you **do** have all 16 pages of the exam and the constant sheet (otherwise inform one of the invigilators).

1. In simple harmonic motion, the speed is greatest at the point in the cycle when
   A. the magnitude of the acceleration is a maximum.
   B. the displacement is maximum.
   C. the magnitude of the acceleration is a minimum.
   D. the potential energy is a maximum.
   E. the kinetic energy is a minimum.

2. A 1.50-kg object connected to a spring with a force constant of 50.0 N/m oscillates on a horizontal, frictionless surface with an amplitude of 4.00 cm. Find the speed of the object when position is 2.00 cm.
   A. 0.20 m/s
   B. 0.66 m/s
   C. 0.12 m/s
   D. 0.94 m/s
   E. 0.81 m/s

3. A sinusoidal wave of frequency f is traveling along a stretched string. The string is brought to rest, and a second traveling wave of frequency $2f$ is established on the string. The wave speed of the second wave is

A. twice that of the first wave
B. half that of the first wave
C. the same as that of the first wave
D. impossible to determine because it depends on the wavelength of the wave
E. impossible to determine because it depends on the amplitude of the wave

4. A sinusoidal wave of wavelength 1.50 m and amplitude 0.20 m travels on a string with a speed of 3.00 m/s to the left. At $t = 0$, the piece of string at $x = 0$ has a displacement of zero and is moving downwards. Find the wave function for this wave.

A. $y(x, t) = (0.20\text{ m}) \sin(4\pi/3\, x + 4\pi t + \pi)$
B. $y(x, t) = (0.20\text{ m}) \sin(4\pi/3\, x + 4\pi t)$
C. $y(x, t) = (0.20\text{ m}) \sin(2\pi/3\, x + 4\pi t)$
D. $y(x, t) = (0.20\text{ m}) \sin(2\pi/3\, x + 4\pi t + \pi)$
E. $y(x, t) = (0.20\text{ m}) \sin(4\pi/3\, x + 2\pi t + \pi)$

5. A standing wave on a string fixed at both ends vibrates in its second normal mode. Suppose the tension is quadrupled while the frequency and the length of the string are held constant. Which standing wave pattern is produced?

A. no standing wave for this condition
B. first normal mode
C. second normal mode
D. fourth normal mode
E. eighth normal mode

6. The A string on a cello vibrates in its second normal mode with a frequency of 70 Hz. The vibrating segment is 120 cm long and has a mass of 2.2 g. Find the tension in the string.

A. 16 N
B. 52 N
C. 3.2 N
D. 62 N
E. 13 N

7. A narrow beam of yellow light with wavelength 589 nm in vacuum is incident from inside the water tank onto a smooth and plane water-air interface at an angle of incidence of 50.0°. Determine (a) the angle of refraction into air, (b) the wavelength, and (c) the speed of light in water (*n* = 1.33).

A. (a) No refraction into air - total internal reflection; (b) 783 nm ; (c) 3.99×10^8 m/s
B. (a) 35°; (b) 443 nm ; (c) 2.26×10^8 m/s
C. (a) No refraction into air - total internal reflection; (b) 443 nm ; (c) 2.26×10^8 m/s
D. (a) 35°; (b) 443 nm ; (c) 3.00×10^8 m/s
E. (a) 35°; (b) 783 nm ; (c) 2.26×10^8 m/s

8. Light with wavelength 450 nm passes through a double slit system that has a slit separation d=0.100 mm. Determine at which distance L the viewing screen must be placed so that dark fringes appear directly opposite both slits, with only one bright fringe between them. Assume L is much greater than d.

A. 2.22 cm
B. 2.20 m
C. 4.22 mm
D. 22.2 cm
E. 4.44 cm

9. Light travelling in glycerin (n = 1.473) strikes a diamond (n = 2.42) at an angle of 60° relative to the normal to the surface. What is the angle of refraction?

A. 20°
B. 60°
C. 32°
D. 64°
E. 15°

10. A thin sheet of plastic (n = 1.60) is inserted between two panes of glass (n =1.52) to reduce infrared (λ = 700 nm) losses. What thickness (in nm) is necessary to produce constructive interference in the reflected infrared radiation?

A. 218
B. 109
C. 55
D. 318
E. 443

11. The moon orbits the Earth and the Earth orbits the sun. What would happen to the orbits of each of these bodies if the force of gravity was suddenly "turned off" everywhere in the universe?

A. Each would slowly spiral away from the Sun.
B. Each would move off in a different straight line.
C. Each would move in the opposite direction from the Sun.
D. Each would fall into the Sun.
E. Nothing; each would continue to orbit the Sun.

12. A satellite is orbiting the Earth at a height h above the Earth's surface. If the mass of the satellite is increased by a factor of 2, the orbital speed of the satellite will

A. reduce by a factor of 4
B. increase by a factor of 4
C. reduce by a factor of 2
D. increase by a factor of 2
E. remain unchanged

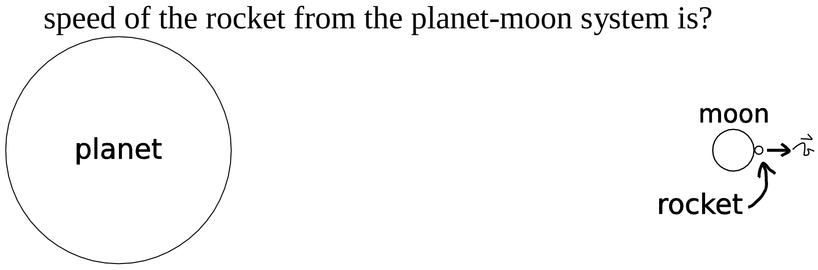
13. Two lead spheres of mass *M* are separated by a distance r; they are isolated in space with no other masses nearby. The magnitude of the gravitational force experienced by each mass is *F*. Now one of the masses is doubled, the other is tripled, and they are pushed farther apart to a separation of 3*r*. Then, the magnitude of the gravitational force on the larger mass is:

A. F
B. 2F
C. F/2
D. 2F/3
E. 3F/2

14. Imagine a body at rest at height *R* from the earth's surface, where *R* is the radius of the earth. If it falls freely under the gravitational pull of the earth, what will be its velocity just before it hits the earth's surface where the acceleration due to gravity is *g*? Neglect the air resistance for the sake of simplicity of the problem. [In a real situation you cannot neglect the air resistance which may even burn the entire body before it reaches the ground!]

A. $\sqrt{2gR}$
B. $\sqrt{gR}$
C. $\sqrt{\frac{2gR}{3}}$
D. $\sqrt{\frac{gR}{3}}$
E. $\sqrt{\frac{gR}{2}}$

15. A moon of mass m_m is in orbit around a planet of mass m_p. Consider a rocket on the surface of this moon, at the point farthest from the planet, as illustrated below. If the distance centre-to-centre between the planet and the moon is R, the radius of the moon is r, then the escape speed of the rocket from the planet-moon system is?



A. $\sqrt{\dfrac{2G(m_p+m_m)}{R^2}}$

B. $\sqrt{\dfrac{2G(m_p+m_m)}{(R+r)^2}}$

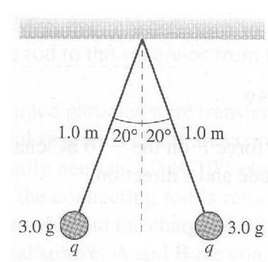
C. $\sqrt{2G(\dfrac{m_p}{R+r}+\dfrac{m_m}{r})}$

D. $\sqrt{\dfrac{2G(m_p+m_m)m_p}{R+r}}$

E. $\sqrt{\dfrac{2Gm_m}{R+r}}$

16. Two 3.0 g spheres on 1.0-m-long threads repel each other after being equally charged. What is the magnitude of the charge q?

A. 238 nC
B. 185 nC
C. 2049 nC
D. 528 nC
E. 746 nC



17. A particle (q = 3.0 mC, m = 20 g) has a speed of 20 m/s when it enters a region where the electric field has a constant magnitude of 80 N/C and a direction which is the same as the velocity of the particle. What is the speed of the particle 3.0 s after it enters this region?

A. 68 m/s
B. 44 m/s
C. 56 m/s
D. 80 m/s
E. 36 m/s

18. When a positive charge is released from rest in a uniform electric field and moves along the electric field line, it will move to a position of

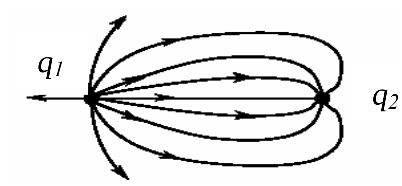
A. higher electric potential and gain electric potential energy
B. higher electric potential and lose electric potential energy
C. lower electric potential and gain electric potential energy
D. lower electric potential and lose electric potential energy
E. equipotential and gain electric potential energy

19. A positive charge $+2q$ lies at x = -1m, and a negative charge $-q$ lies at x = 1m. The point on the x-axis where the electric field is zero is

A. 0.18m
B. 0.67m
C. 0.00m
D. -0.83m
E. 5.83m

20. The figure below shows the electric field lines in the vicinity of two point charges. Which one of the following statements concerning this situation is true?

A. q_1 is negative and q_2 is positive.
B. The magnitude of the ratio (q_2/ q_1) is less than one.
C. Both q_1 and q_2 have the same sign of charge.
D. The magnitude of the electric field is the same everywhere.
E. The electric field is strongest midway between the charges.



21. Two charged particles, Q_1 and Q_2, are 6 cm apart with $Q_2 = 6Q_1$. Compare the forces they exert on one another when $\vec{F}_1$ is the force Q_2 exerts on Q_1 and $\vec{F}_2$ is the force Q_1 exerts on Q_2.

A. $\vec{F}_2 = 6\vec{F}_1$

B. $\vec{F}_2 = -6\vec{F}_1$

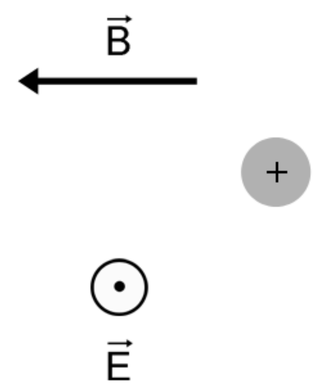
C. $\vec{F}_2 = -\vec{F}_1$

D. $\vec{F}_2 = \vec{F}_1$

E. $6\vec{F}_2 = \vec{F}_1$

22. In the diagram, a positively charged particle moves through a uniform magnetic field directed to the left, and a uniform electric field directed out of the page. In what direction must the particle move to experience a net force of zero?

A. To the left of the page
B. To the right of the page
C. To the bottom of the page
D. Out of the page
E. Into the page



23. An electron has a velocity of 6.0×10^6 m/s in the positive x direction at a point where the magnetic field has the components $B_x = 3.0$ T and $B_y = 1.5$ T. What is the magnitude of the acceleration of the electron at this point?

A. 2.1×10^{18} m/s^2
B. 1.6×10^{18} m/s^2
C. 2.6×10^{18} m/s^2
D. 3.2×10^{18} m/s^2
E. 3.5×10^{18} m/s^2

24. A 2.0-m wire carries a current of 15 A directed along the positive x axis in a region where the magnetic field is uniform and given by $B = (30\hat{\mathbf{i}} - 40\hat{\mathbf{j}})$ mT. What is the resulting magnetic force on the wire?

A. $(+1.2\,\hat{\mathbf{k}})$ N
B. $(-1.2\hat{\mathbf{k}})$ N
C. $(-1.5\,\hat{\mathbf{k}})$ N
D. $(+1.5\,\hat{\mathbf{k}})$ N
E. $(+0.90\,\hat{\mathbf{k}})$ N

25. What is the kinetic energy of an electron that passes undeflected through perpendicular electric and magnetic fields if E = (- 4.0 $\hat{\mathbf{j}}$) kV/m and B = (- 8.0 $\hat{\mathbf{k}}$) mT?

A. 0.65 eV
B. 0.71 eV
C. 0.84 eV
D. 0.54 eV
E. 1.4 eV

26. An infinitely long wire centered on the origin carries a 20-A current directed in the positive y direction. Determine the magnetic field at the point x = 5.0 m on the x-axis.

A. 1.6 nT in the negative z direction
B. 8.0 μT in the positive z direction
C. 2.5 nT in the negative z direction
D. 0.8 μT in the negative z direction
E. None of the above

27. Two long parallel wires lie in the *xz* plane. One wire passes through the point (–2 m, 0, 0) and the other through the point (+2 m, 0, 0). The wires carry equal currents in the positive *z* direction. Which of the following statements are correct?

1. The magnetic field at (–3 m,0,0) is in the negative *y* direction.
2. The magnetic field at (–1 m,0,0) is in the positive *y* direction.
3. The magnetic field at (+1 m,0,0) is in the positive *y* direction.
4. The magnetic field at (+3 m,0,0) is in the negative *y* direction.

A. 1 and 2 are correct.
B. 1 and 4 are correct.
C. 2 and 3 are correct.
D. 3 and 4 are correct.
E. None of the above are correct.

Some Physical Constants

Quantity	Symbol	Value[a]
Atomic mass unit	u	$1.660\,538\,86\ (28) \times 10^{-27}$ kg $931.494\,043\ (80)$ MeV/c^2
Avogadro's number	N_A	$6.022\,141\,5\ (10) \times 10^{23}$ particles/mol
Bohr magneton	$\mu_B = \frac{e\hbar}{2m_e}$	$9.274\,009\,49\ (80) \times 10^{-24}$ J/T
Bohr radius	$a_0 = \frac{\hbar^2}{m_e e^2 k_e}$	$5.291\,772\,108\ (18) \times 10^{-11}$ m
Boltzmann's constant	$k_B = \frac{R}{N_A}$	$1.380\,650\,5\ (24) \times 10^{-23}$ J/K
Compton wavelength	$\lambda_C = \frac{h}{m_e c}$	$2.426\,310\,238\ (16) \times 10^{-12}$ m
Coulomb constant	$k_e = \frac{1}{4\pi\epsilon_0}$	$8.987\,551\,788 \ldots \times 10^9$ N·m²/C² (exact)
Deuteron mass	m_d	$3.343\,583\,35\ (57) \times 10^{-27}$ kg $2.013\,553\,212\,70\ (35)$ u
Electron mass	m_e	$9.109\,382\,6\ (16) \times 10^{-31}$ kg $5.485\,799\,094\,5\ (24) \times 10^{-4}$ u $0.510\,998\,918\ (44)$ MeV/c^2
Electron volt	eV	$1.602\,176\,53\ (14) \times 10^{-19}$ J
Elementary charge	e	$1.602\,176\,53\ (14) \times 10^{-19}$ C
Gas constant	R	$8.314\,472\ (15)$ J/mol·K
Gravitational constant	G	$6.674\,2\ (10) \times 10^{-11}$ N·m²/kg²
Josephson frequency–voltage ratio	$\frac{2e}{h}$	$4.835\,978\,79\ (41) \times 10^{14}$ Hz/V
Magnetic flux quantum	$\Phi_0 = \frac{h}{2e}$	$2.067\,833\,72\ (18) \times 10^{-15}$ T·m²
Neutron mass	m_n	$1.674\,927\,28\ (29) \times 10^{-27}$ kg $1.008\,664\,915\,60\ (55)$ u $939.565\,360\ (81)$ MeV/c^2
Nuclear magneton	$\mu_n = \frac{e\hbar}{2m_p}$	$5.050\,783\,43\ (43) \times 10^{-27}$ J/T
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ T·m/A (exact)
Permittivity of free space	$\epsilon_0 = \frac{1}{\mu_0 c^2}$	$8.854\,187\,817 \ldots \times 10^{-12}$ C²/N·m² (exact)
Planck's constant	h $\hbar = \frac{h}{2\pi}$	$6.626\,069\,3\ (11) \times 10^{-34}$ J·s $1.054\,571\,68\ (18) \times 10^{-34}$ J·s
Proton mass	m_p	$1.672\,621\,71\ (29) \times 10^{-27}$ kg $1.007\,276\,466\,88\ (13)$ u $938.272\,029\ (80)$ MeV/c^2
Rydberg constant	R_H	$1.097\,373\,156\,852\,5\ (73) \times 10^7$ m^{-1}
Speed of light in vacuum	c	$2.997\,924\,58 \times 10^8$ m/s (exact)

Note: These constants are the values recommended in 2002 by CODATA, based on a least-squares adjustment of data from different measurements. For a more complete list, see P. J. Mohr and B. N. Taylor, "CODATA Recommended Values of the Fundamental Physical Constants: 2002." *Rev. Mod. Phys.* 77:1, 2005.

[a] The numbers in parentheses for the values represent the uncertainties of the last two digits.

Useful trigonometric identities:

$$\sin(a \pm b) = \sin(a)\cos(b) \pm \cos(a)\sin(b)$$

$$\sin(a) + \sin(b) = 2\cos\left(\frac{a-b}{2}\right)\sin\left(\frac{a+b}{2}\right)$$