ILC CEI
INDEPENDENT LEARNING CENTRE
CENTRE D'ÉTUDES INDÉPENDANTES

Physics SPH4U-C
Practice Test

Time: 2 hours
Total Marks: 101 **Final Test Score: ____ ÷ 101 × 100 = ____%**

Instructions

- There is a label attached to this page. Compare the course code on the label with the course code printed on the Final Test to make sure that they are the same. Inform the Final Test supervisor **immediately** if they are not the same.
- The Final Test pages are numbered 1 through 22. Check to see that all 22 pages are attached. Inform the Final Test supervisor **immediately** if there are any pages missing.
- You may use a non-marked dictionary during the Final Test if one is available at the test site. You may not bring any books or notes into the test.
- You will need a pen and calculator.
- You must write your answers in the space provided.
- There are five (5) parts to this Final Test. A breakdown of the marks and the approximate time required is given below. Look over the test carefully before you begin. Manage your time carefully and leave some time at the end to review your work.

Part	Activity	Marks	Time (min)
Preview			5
A	Dynamics	23	22
B	Energy and Momentum	22	22
C	Gravitational, Electric, and Magnetic Fields	20	22
D	The Wave Nature of Light	15	22
E	Modern Physics	21	22
Review			5
Total		**101**	**120**

- At the end of the Final Test, return this test paper, and any other paper you write on, to the Final Test supervisor.
- Please note that, for security reasons, marked tests are not returned to students.

November 19, 2014

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Formula Sheet—Physics SPH4U-C

Displacement, Velocity, Acceleration

$$\vec{v} = \frac{\Delta\vec{d}}{\Delta t} \text{ which becomes } \Delta\vec{d} = \left(\frac{\vec{v}_1 + \vec{v}_2}{2}\right)\Delta t$$

$$\left.\begin{aligned} \vec{a} &= \frac{\Delta\vec{v}}{\Delta t} \\ &= \frac{\vec{v}_2 - \vec{v}_1}{\Delta t} \end{aligned}\right\} \text{which becomes } \vec{v}_2 = \vec{v}_1 + \vec{a}\Delta t$$

$$\Delta\vec{d} = \vec{v}_1\Delta t + \frac{1}{2}\vec{a}\Delta t^2$$

$$\Delta\vec{d} = \vec{v}_2\Delta t - \frac{1}{2}\vec{a}\Delta t^2$$

$$v_2^2 = v_1^2 + 2a\Delta d$$

Physical Constants

$G = 6.67 \times 10^{-11}\ \frac{\text{Nm}^2}{\text{kg}^2}$

$k = 9.0 \times 10^{9}\ \frac{\text{Nm}^2}{\text{C}^2}$

$e = 1.60 \times 10^{-19}$ C

Mass of $e = 9.11 \times 10^{-31}$ kg

$g = 9.8$ m/s^2

$h = 6.63 \times 10^{-34}$ Js

$c = 3.00 \times 10^{8}$ m/s

Mass of proton $= 1.67 \times 10^{-27}$ kg

Force

$$\vec{F}_{\text{net}} = m\vec{a}$$

$$\vec{F}_{\text{net}} = \Sigma\vec{F}_{\text{on FBD}}$$

$$F_g = mg \quad \text{and} \quad F_g = \frac{GM_1M_2}{r^2}$$

$F_f = \mu F_N$ (either static or kinetic)

$$F_s = kx$$

Useful Data

Body	Mass (kg)	Radius (m)
Earth	5.98×10^{24}	6.38×10^{6}
Sun	1.99×10^{30}	6.96×10^{8}
Moon	7.35×10^{22}	1.74×10^{6}

Circular Motion

$$v = \frac{2\pi r}{T} \qquad T = \frac{1}{f}$$

$$a_c = \frac{v^2}{r} \qquad \vec{F}_{\text{net}_{\text{CIRCULAR}}} \text{ is } \vec{F}_c \qquad F_c = \frac{mv^2}{r}$$

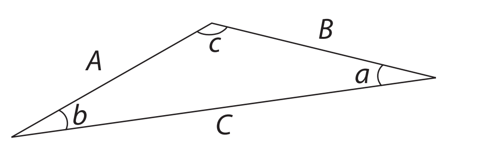
$$a_c = 4\pi^2 rf^2 \qquad F_c = m4\pi^2 rf^2$$

$$a_c = \frac{4\pi^2 r}{T^2} \qquad F_c = \frac{m4\pi^2 r}{T^2}$$

Basic Math Formulae

$$ax^2 + bx + c = 0$$

$$x = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$



$$A^2 = B^2 + C^2 - 2BC\cos a$$

$$\frac{A}{\sin a} = \frac{B}{\sin b} = \frac{C}{\sin c}$$

Prefixes

G	giga-	10^{9}
M	mega-	10^{6}
k	kilo-	10^{3}
d	deci-	10^{-1}
c	centi-	10^{-2}
m	milli-	10^{-3}
µ	micro-	10^{-6}
n	nano-	10^{-9}

Momentum

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

$\underset{\text{(impulse)}}{\vec{F}\Delta t} = \Delta\vec{p}$

$\vec{F}\Delta t = m(\vec{v}_2 - \vec{v}_1)$

Conservation of momentum

$\vec{p}_{\mathrm{T_{initial}}} = \vec{p}_{\mathrm{T_{final}}}$

For elastic collisions and object 2 at rest

$$v_{1_\mathrm{f}} = \left(\frac{m_1 - m_2}{m_\mathrm{T}}\right)v_{1_\mathrm{o}}$$

$$v_{2_\mathrm{f}} = \left(\frac{2m_1}{m_\mathrm{T}}\right)v_{1_\mathrm{o}}$$

$(m_\mathrm{T} = m_1 + m_2)$

("o" initial "f" final)

Energy

$\underset{\text{(work)}}{W} = \Delta E = E_2 - E_1$

$W = \vec{F}\Delta\vec{d}$

$\quad = F\Delta d\cos\theta$

$E_\mathrm{k} = \frac{1}{2}mv^2$

$E_{\mathrm{p_{gravity}}} = mg\Delta h$

$E_{\mathrm{p_{spring}}} = \frac{1}{2}kx^2$

Conservation of energy

$E_{\mathrm{T_{initial}}} = E_{\mathrm{T_{final}}}$

$E_\mathrm{T} = (E_{\mathrm{p_g}} + E_{\mathrm{p_s}}) + E_\mathrm{k}$

(In general $E_\mathrm{T} = E_\mathrm{p} + E_\mathrm{k}$)

For oscillating springs

$$T = 2\pi\sqrt{\frac{m}{r}}$$

Electric Fields

$F = \frac{kq_1q_2}{r^2}$ $\quad E = \frac{kq_1q_2}{r}$

$q = ne$ (n is an integer)

$\vec{\varepsilon} = \frac{\vec{F}}{q}$ $\quad V = \frac{E}{q}$

$\varepsilon = \frac{kq}{r^2}$ $\quad V = \frac{kq}{r}$

$\varepsilon = \frac{\Delta V}{r}$ $\quad \Delta E = q\Delta V$

Magnetic Fields

$\vec{F} = q\vec{v} \times \vec{B}$ (particle)

$\quad = qvB\sin\theta$

$\quad = qvB$ ($\theta = 90°$)

$F = ILB$ (wire)

$\vec{B}$ is measured in teslas (T)

Classical Light (Wave Nature)

$c = \lambda f$

Thin Films

$\frac{\lambda}{2}$ shift for $n_1 < n_2$

0 shift for $n_1 > n_2$

path difference $= 2t$

Interference

A) Double Slit

Maxima

$m_\lambda =$ path difference

$= |P_mS_1 - P_mS_2|$

$m\lambda = d\sin\theta_m$

$m\lambda = \frac{dx_m}{L}$

For minima use $\left(n - \frac{1}{2}\right)\lambda$

$\Delta x = \frac{L\lambda}{d}$

B) Diffraction Grating

$d = \frac{\text{size of opening}}{\text{\# slits}}$

$d = \frac{1}{\text{line density}}$

Maxima

$m\lambda = d\sin\theta_m$

$m\lambda = \frac{dx_m}{L}$

For minima use $\left(n - \frac{1}{2}\right)\lambda$

$\Delta x = \frac{L\lambda}{d}$

C) Single slit diffraction

Minima

$n\lambda = w\sin\theta_n$

$n\lambda = \frac{dy_n}{L}$

For maxima use $(m + 1)\lambda$

$\Delta y = \frac{L\lambda}{w}$

Modern Physics

$c = \lambda f \quad E = hf \quad E = \frac{hc}{\lambda}$

Photoelectric Effect

$hf = w + E_k$

$hf_o = w$

threshold frequency (f_o)

$E_k = eV$

retarding voltage (current = 0) (V)

(Note: $1eV = 1.60 \times 10^{-19}$ J)

Compton Effect

$\frac{hc}{\lambda_1} = \frac{hc}{\lambda_2} + \frac{1}{2}mv^2$

$p = \frac{h}{\lambda}$

de Broglie wavelength

$\lambda = \frac{h}{p} \qquad \lambda = \frac{h}{mv}$

Relativity

$\Delta t_m = \frac{\Delta t_s}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$

$E_{total} = \frac{mc^2}{\sqrt{1 - \frac{v^2}{c^2}}}$

$L_m = L_s\sqrt{\left(1 - \frac{v^2}{c^2}\right)}$

$E_{rest} = mc^2$

$m_m = \frac{m_s}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$

$E_k = E_{total} - E_{rest}$

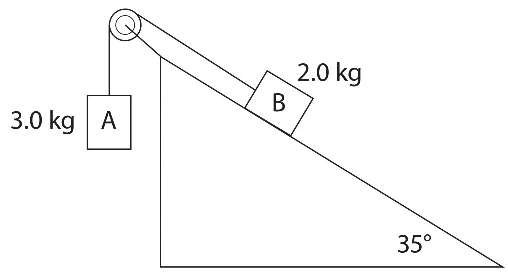
subscript "s" : observer at rest with respect to the event

subscript "m" : observer in motion with respect to the event

Part A: Dynamics (23 marks) (*approximate time: 22 minutes*)

1. A 0.50 kg football is thrown from a height of 1.8 m with an initial velocity of 15.0 m/s [R 34° U] (34° above the horizontal axis). Assuming that there is no interference and that the ball lands on the ground, how far will the ball travel horizontally? **(6 marks)**

2. A block on an inclined surface is connected to another block that is hanging over the top edge of the incline, as shown in the following diagram. The blocks in the system are moving in such a way that block A (with a mass of 3.0 kg) is moving downwards, as block B (with a mass of 2.0 kg) slides up the ramp. The coefficient of kinetic friction between the ramp and the sliding block is 0.11. Determine the magnitude of acceleration of each of the blocks below, and the magnitude of force of tension in the string. **(9 marks)**



3. Complete **ONE** of the following. **Clearly indicate whether you are answering #3 Choice 1 or #3 Choice 2. (8 marks)**

Choice 1:

A canoe travelling at 60.0 km/h [S] with respect to the water ends up travelling 30.0 km/h [S 45° W] with respect to the shore, due to the current. Use your knowledge of vector components to calculate the current's velocity.

OR

Choice 2:

A 0.050 kg yo-yo is swung in a vertical circle on the end of its 0.30 m long string at the slowest speed that the yo-yo can have.

a) What is this speed? Include a labelled free-body diagram with your answer.

b) What will the maximum tension in the string be when the yo-yo is swung in a vertical circle at this speed? Where will this maximum tension occur? Include a labelled free-body diagram with your answer.

Part B: Energy and Momentum (22 marks) (*approximate time: 22 minutes*)

4. A 0.065 kg object is attached to a spring with a spring constant of 100.0 N/m. The other end of the spring is attached to a wall in such a way that it rests on a frictionless horizontal surface. A force is exerted on the spring so that it experiences simple harmonic motion. **(10 marks)**

a) How much work would be done on this spring to compress it by 11.0 cm?

b) Assuming that there is no friction, describe the energy conversions that take place, being sure to explain the location of maximum elastic potential energy and maximum kinetic energy.

c) What will the speed of the object be when it is passing the point of being compressed by only 5.5 cm? (Assume that the mass of the spring is negligible.)

5. Magnetic puck A, with a mass of 0.100 kg, is pushed towards stationary 0.050 kg magnetic puck B, to cause a head-on collision. You may neglect friction. The initial velocity of puck A is 12 m/s [E]. Puck B moves with a velocity of 14 m/s [E], after the collision.

a) Find the velocity of puck A after the collision. **(3 marks)**

b) Find the net force acting on puck A if the collision takes 0.20 s. **(3 marks)**

6. Skater A, with a mass of 72.0 kg, is moving at 11.0 m/s [S] when he collides with skater B, with a mass of 42.0 kg, moving at 14.0 m/s [E]. The collision is completely inelastic and the two skaters move off together after the collision. Find the velocity of the skaters, right after the collision. **(6 marks)**

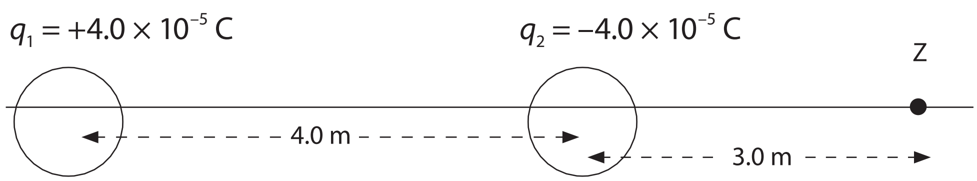
Part C: Gravitational, Electric, and Magnetic Fields (20 marks) (*approximate time: 22 minutes*)

7. A 200 kg satellite is in circular orbit at a height of 600 km above the earth's surface.

a) Find the speed of the satellite. **(4 marks)**

b) Find the gravitational field strength at this altitude. **(3 marks)**

8. Examine the charge distribution shown.



a) What will the net force be on a third charge of $q_3 = -3.0 \times 10^{-5}$ C, placed at point Z? **(4 marks)**

b) What will the total electric potential energy be if a third charge of -3.0×10^{-5} C is placed at point Z? **(4 marks)**

9. A magnetic field of 2.2 T [down] is 3.0 m wide.

a) Find the magnetic force on a proton moving at 3.0×10^{5} m/s [east] in the field. **(3 marks)**

b) Find the radius of the circular path of the proton. **(2 marks)**

Part D: The Wave Nature of Light (15 marks) (*approximate time: 22 minutes*)

10. In an investigation to test Thomas Young's double-slit experiment, a helium–neon laser is used to produce an interference pattern on a screen.

a) Use the following measurements to determine the wavelength of light in three different ways. **(4 marks)**

- The angle to the eighth maximum is 3.08°.
- The distance from the slits to the screen is 2.00 m.
- The distance from the first minimum to the fifth minimum is 5.38 cm.
- The distance between the slits is 0.0950 mm.
- The distance from the centre of the pattern to the sixth maximum is 8.06 cm.

b) What are two possible changes that would each result in an increase in the distance between the nodal lines? **(2 marks)**

c) What changes would occur if (i) one of the slits were covered or (ii) the light were shone through a diffraction grating? What would cause these changes? **(3 marks)**

11. Answer **ONE** of the following questions. **Clearly indicate whether you are answering #11 Choice 1, #11 Choice 2, or #11 Choice 3. (6 marks)**

Choice 1:

What type of wave is light, and how is light energy propagated through space? How are these types of waves created, for example, with an oscillator?

OR

Choice 2:

Light can be polarized. Explain what this means, and how it influences our understanding of the type of wave that light is. Briefly describe two ways in which light is naturally polarized. Describe one application of light-polarizing materials.

OR

Choice 3:

a) What is dispersion? Explain why it happens.

b) When sunlight hits the thin film of a soap bubble, only red and green colours seem to be reflected. Why is this? What happened to the other colours?

Part E: Modern Physics (21 marks) (*approximate time: 22 minutes*)

12. In 2010, a 20-year-old astronaut leaves her twin on earth and goes on a rocket to explore the galaxy. The rocket moves at 2.7×10^8 m/s during the voyage. It returns to earth in the year 2040.

a) Using relativity, calculate the age of the returning astronaut. **(3 marks)**

b) Find the length of the rocket in earth's frame of reference when it is moving, given that the rest length is 120 m. Assume you are a stationary observer viewing the rocket from the side. **(3 marks)**

c) Find the relativistic mass of the rocket when it is moving, given that the rest mass is 150 000 kg. **(3 marks)**

13. Light with a wavelength of 550 nm illuminates a metallic surface with a work function of 1.10 eV.

a) What is the maximum speed of the photoelectrons? **(4 marks)**

b) What is the minimum potential required to stop the electrons? **(2 marks)**

14. Given a photon with wavelength 520 nm, find the energy and momentum of the photon. What equivalent mass would a particle have if all the energy of the photon were converted to mass? **(6 marks)**