For office use only: _____

The University of Sydney

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Quantum Physics Concept Survey

This survey is part of a project being undertaken by the Sydney University Physics Education Research Group (SUPER). Thank you for agreeing to take part in the survey; it should not take longer than about **30 minutes** to complete.

Participation in this project by completing this survey is completely voluntary. No information about individual answers or your identity will be given to people teaching or assessing the course.

Name_____

SID_____

GENDER ○ Female ○ Male

General Information

1. In what year did you study Physics I?

○ 2005
○ 2004
○ Earlier

2. At what level did you study Physics I?

○ Advanced
○ Regular
○ Fundamental

3. Did you study the physics options "Quanta to Quarks" in high school?

○ Yes
○ No
○ Don't remember

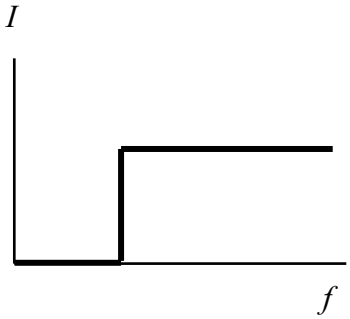
4. Are you studying any courses involving Modern Physics or Quantum Physics in semester 1, 2006?

○ No
○ Yes (give details)

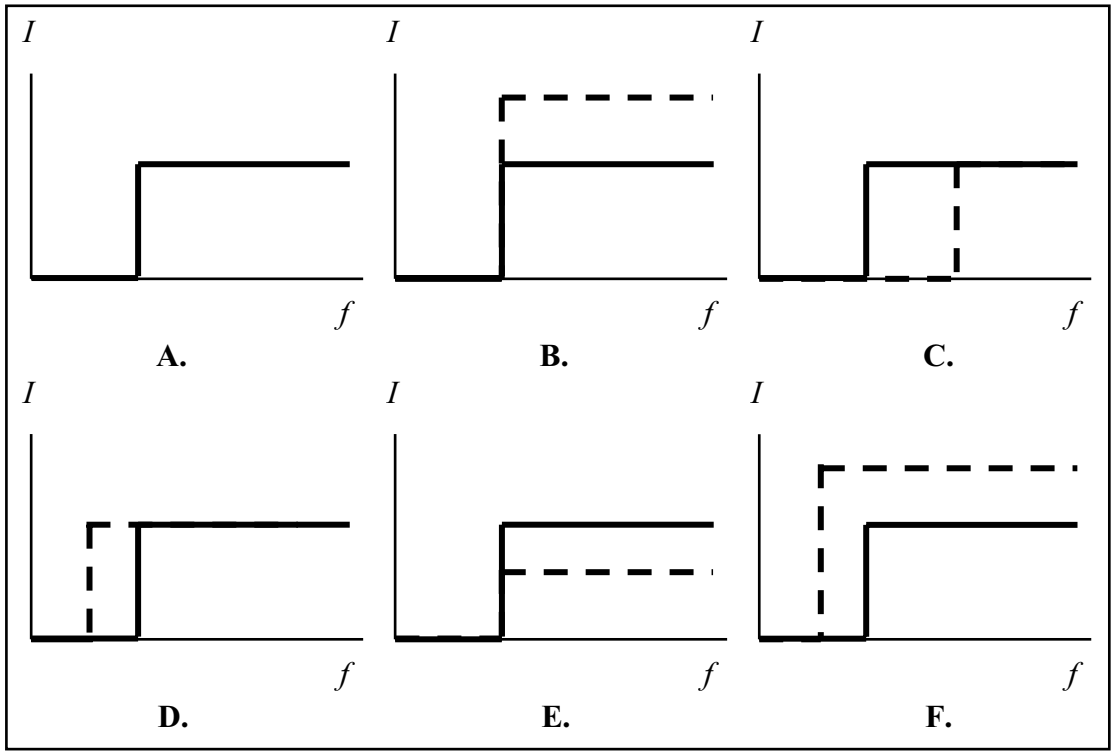
Concepts in Quantum Physics

Questions 1 through 3 refer to the following.

In a hypothetical experiment to demonstrate the photoelectric effect, a light source of variable frequency is shone on a photo-sensitive surface. Ejected photoelectrons are collected by an anode which is at a potential lower (more negative) than the surface. The resulting photocurrent (I) as a function of frequency (f) is shown below.



Select your answers to the questions below from these graphs.



Which graph would be most appropriate if	**Your answer** ⇓
1. the intensity of the light is increased?	
2. the work function of the surface is increased?	
3. the potential difference between the surface and anode is made even more negative?	

4. In the photoelectric effect a cut-off frequency is always observed. We believe that this speaks in favour of the particle theory of light rather than the wave theory. Which of the following statements support this belief? (You may choose more than one.)

   A. An electromagnetic **wave** of very low frequency cannot give energy to electrons.
   B. Only **particles** with more than a minimum energy can give the electrons enough energy to escape.
   C. An electromagnetic **wave** of any frequency should be able to give any amount of energy to an electron, if its amplitude is large enough.

For question 4: How confident are you that your answer is correct? (circle one)

33% 66% 100%

Questions 5 through 8 refer to the following experiments.
In one experiment electrons are traveling from a source to a photoelectric screen.
In a second experiment light is traveling from a source to a photographic plate.

Circle the most appropriate answer to each of the following questions.

5. When the electron travels from the source to the screen,

   A. it is behaving like a particle.
   B. it is behaving like a wave.
   C. it is behaving like both a particle and a wave.
   D. you cannot tell if it is behaving like a particle or a wave.

6. When light travels from the source to the plate,

   A. it is behaving like a particle.
   B. it is behaving like a wave.
   C. it is behaving like both a particle and a wave.
   D. you cannot tell if it is behaving like a particle or a wave.

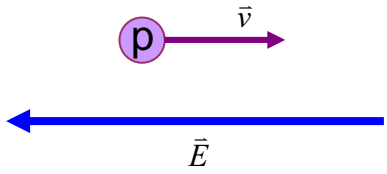
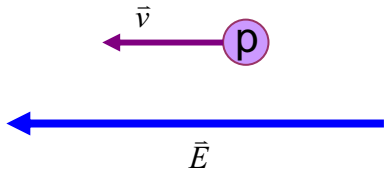
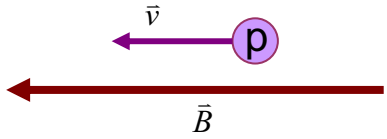
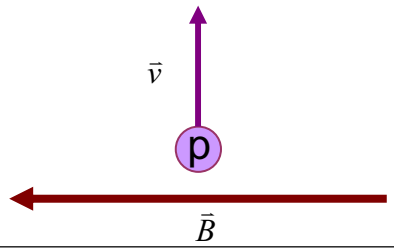
7. When the electron interacts with the screen,

   A. it is behaving like a particle.
   B. it is behaving like a wave.
   C. it is behaving like both a particle and a wave.
   D. you cannot tell if it is behaving like a particle or a wave.

8. When the light interacts with the plate,

   A. it is behaving like a particle.
   B. it is behaving like a wave.
   C. it is behaving like both a particle and a wave.
   D. you cannot tell if it is behaving like a particle or a wave.

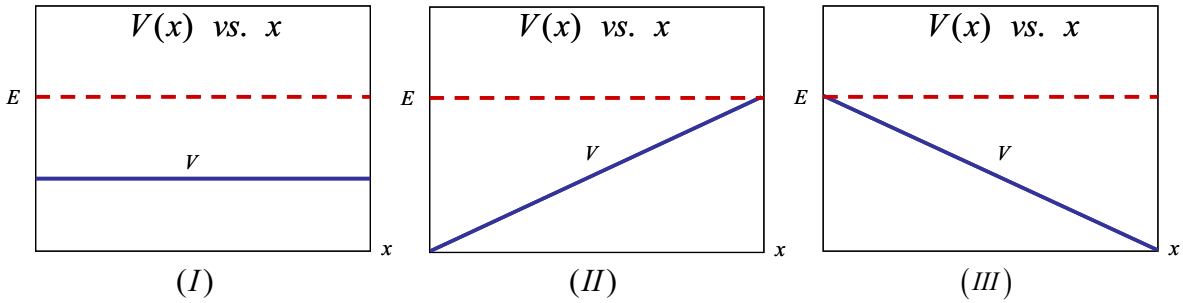
9. The figure below shows four situations in which a proton is moving through an electric or magnetic field. Its motion is,

(*I*) opposite to the electric field 	(*II*) in the same direction as the electric field 
(*III*) in the same direction as the magnetic field 	(*IV*) perpendicular to the magnetic field 

In which situations is the de Broglie wavelength of the proton increasing, decreasing or constant? Put a tick in the appropriate box.

Figure	Increasing	Decreasing	Constant
I			
II			
III			
IV			

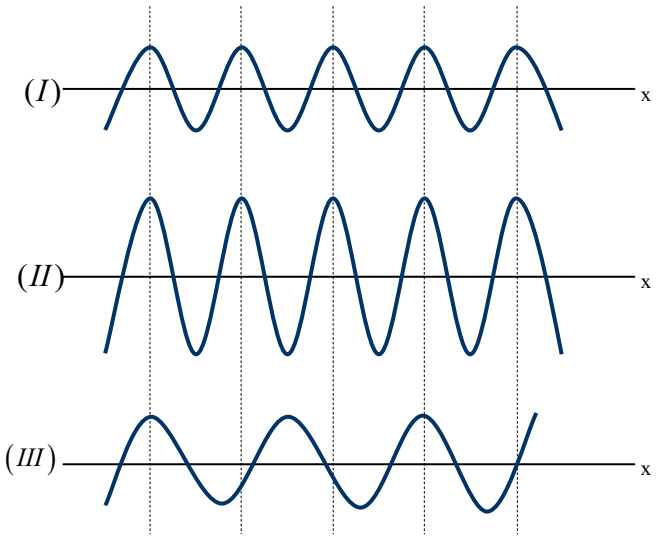
10. Quantum particles are traveling from the left to right with equal total energy, E. They enter a region in which the potential energy, V, is as shown in these diagrams.



In which situation is the de Broglie wavelength of the particle increasing, decreasing or constant? Put a tick in the appropriate box.

Figure	Increasing	Decreasing	Constant
I			
II			
III			

11. Three particles of equal mass are traveling in the same direction. The de Broglie wave of each of the three particles looks like this



Rank the speeds of the particles (I), (II) and (III) by circling one of these four possibilities.

A. $v_{II} > v_I > v_{III}$
B. $v_{II} > v_{III} > v_I$
C. $v_I = v_{II} > v_{III}$
D. $v_{II} > v_I = v_{III}$

For question 11: How confident are you that your answer is correct? (circle one)

25% 50% 75% 100%

Questions 12 through 16 refer to the following experiments.

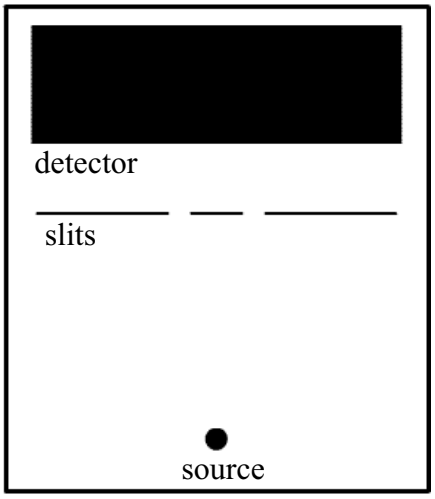
In one experiment electrons are traveling from a source to a photoelectric screen, through a double slit.

In a second experiment light is traveling from a source to a photographic plate, through a double slit.

In a third experiment marbles are traveling from a source to an array of collecting bins, through two slit-like openings, side by side.

The right-hand figure shows the experimental set-up and the figures below show roughly the possible patterns which could be detected on the various screens.

Top view of experimental set-up (not to scale)



Possible patterns (not to scale)

A

B

C

D

Some other pattern

Which pattern would you expect to observe when,

Your answer ⇓

12. ***light*** passes through the double slit. [ ]

13. ***marbles*** pass through the double opening. [ ]

14. ***electrons*** pass through the double slit. [ ]

15. ***light*** passes through the apparatus when ***one of the slits is covered***. [ ]

16. ***electrons*** pass through the apparatus when ***one of slits is covered***. [ ]

In questions 17 and 18, circle the most appropriate answer.

17. According to the uncertainty principle, the more we know about an electron's position, the less we know about its,

A. speed
B. momentum
C. kinetic energy
D. all of these
E. none of these

For question 17: How confident are you that your answer is correct? (circle one)

20% 40% 60% 80% 100%

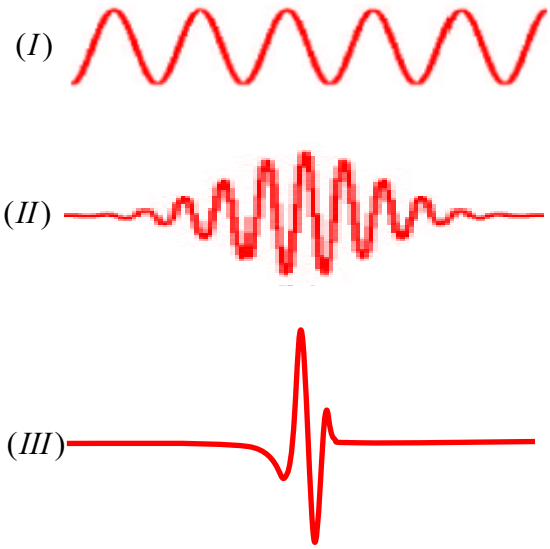
18. The Heisenberg Uncertainty Principle is mostly applied to very small objects such as electrons and protons. Why don't we use the uncertainty relation on larger objects such as cars and tennis balls?

A. Because current technology is not sophisticated enough to detect the properties of very small objects with sufficient accuracy.
B. Because large objects at any instant of time have an exact position and exact momentum and with sufficient care we can measure both precisely.
C. Because large objects obey Newton's laws of motion, to which the uncertainty principle does not apply.
D. Because it does apply to large objects, but the uncertainties are so small that we don't notice them.
E. Other answer.

For question 18: How confident are you that your answer is correct? (circle one)

20% 40% 60% 80% 100%

19. Shown below are three wave packets.



Which description best describes each wave packet? Put a tick in the appropriate box.

	Figure *I*	Figure *II*	Figure *III*	None
(a) poorly defined position, well defined wavelength				
(b) well defined position, poorly defined wavelength				
(c) well defined position, well defined wavelength				
(d) poorly defined position, poorly defined wavelength				

20. For the double slit experiment with electrons, which of the following statements is/are **TRUE**? (You may choose more than one statement)

A. It is in principle possible to measure which slit an electron went through and still see an interference pattern, if the technology is sophisticated enough.
B. It is possible to measure which slit an electron went through, but if you make this measurement, the beam of electrons will no longer form the interference pattern on the screen.
C. Each electron must have gone through one slit or the other, but it is impossible to measure which slit any one particular electron went through.

For question 20: How confident are you that your answer is correct? (circle one)

33% 66% 100%