Name: _____ Student #: _____

THOMPSON RIVERS UNIVERSITY

PHYS 1150
Mechanics & Waves

Instructor: Richard Taylor

FINAL EXAM

9 December 2014 14:00–17:00

Instructions:

1. Read the whole exam before beginning.
2. Make sure you have all 8 pages.
3. Organization and neatness count.
4. Justify your answers.
5. Clearly show your work.
6. You may use the backs of pages for calculations.
7. You may use an approved formula sheet.
8. You may use an approved calculator.

PROBLEM	GRADE	OUT OF
1		10
2		10
3		7
4		5
5		12
6		13
7		8
8		7
9		8
TOTAL:		80

/10

Problem 1: A thin anti-reflective coating ($n = 1.38$) is applied to a glass lens ($n = 1.5$) in order to eliminate reflections. Answer the following, being sure to include diagrams and explain your reasoning.

(a) What is the minimum thickness of the coating in order to eliminate reflections of blue (450 nm) light at normal incidence?

/4

(b) For the film thickness you found in part (a), what are the three longest wavelengths for which light transmitted into the air behind the lens is brightest?

/4

(c) Suppose the film's thickness is decreased slightly. This changes the wavelength of reflected light that undergoes destructive interference in part (a). Does the wavelength increase, or decrease? Explain.

/2

/10

Problem 2: A stamp collector uses a converging lens with focal length 24 cm to view a stamp 18 cm in front of the lens.

(a) Sketch a ray diagram that locates the stamp's image. Is the image real, or virtual? Upright, or inverted?

/6

(b) Calculate the distance of the image from the lens.

/2

(c) Calculate the magnification.

/2

/7 **Problem 3:** A world-class sprinter can reach a top speed (of about 11.5 m/s) in the first 15.0 m of a race.

/2 (a) How long does is take the sprinter to reach her top speed, assuming she starts from rest?

/3 (b) What is her average acceleration during the first 15.0 m?

/2 (c) Assume the sprinter has a mass of 60.0 kg and that her acceleration during the first 15.0 m of the race is due to a constant net force in her direction of motion. What is the magnitude of this force?

/5 **Problem 4:** A child sits 9.0 m from the center of a circular merry-go-round ride that rotates in a horizontal circle at a constant rate of 5.0 revolutions per minute. Calculate:

/3 (a) the centripetal acceleration of the child.

/2 (b) the net horizontal force on the child (assuming their mass is 25 kg).

/12

Problem 5: A high diver leaves the end of a 5.0 m-high diving board and strikes the water 1.3 s later, 3.0 m beyond the end of the board. Determine:

(a) her initial velocity $\mathbf{v}_0$.

/3

(b) the maximum height (above the water) that she reaches.

/3

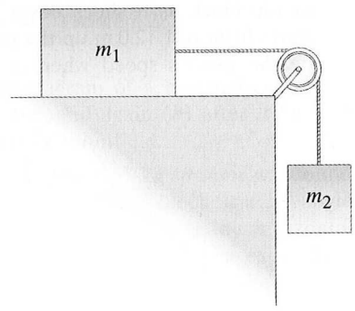
(c) the final velocity $\mathbf{v}_f$ with which she enters the water.

/3

(d) the angle (below horizontal) at which she enters the water.

/3

/13 **Problem 6:** The diagram below shows a block (mass m_1) on a smooth horizontal surface, connected by a thin cord that passes over a pulley to a second block (m_2), which hangs vertically. Ignore friction and the masses of the pulley and cord.



/3 (a) Draw a free-body diagram for each block, indicating all non-negligible forces.

/4 (b) Determine a formula (in terms of m_1, m_2 and g) for the acceleration of the system.

/2 (c) Determine a formula (in terms of m_1, m_2 and g) for the tension in the cord.

/4 (d) Now assume that the coefficient of kinetic friction between the block m_1 and the table is $\mu = 0.20$. Suppose $m_1 = m_2 = 5.0\,\text{kg}$. Find the acceleration of the system in this case.

/8 **Problem 7:** A vertical spring (of negligible mass), with spring constant 900 N/m, is attached to a table and is compressed down by 0.150 m.

/4 (a) What upward speed can it give to a 0.300 kg ball when released?

/4 (b) To what maximum height above its original position (spring compressed) will the ball rise?

/7 **Problem 8:** A (massless) spring vibrates with a frequency of 3.0 Hz and amplitude 5.0 cm when a mass of 0.50 kg is attached to it.

/2 (a) Calculate the maximum speed of the mass.

/2 (b) Calculate the maximum acceleration of the mass.

/3 (c) What will be the frequency of vibration if only 0.35 kg is attached to the spring?

/8

Problem 9: In one of the original Doppler experiments, one tuba was played at a frequency of 75 Hz on a moving train car, and a second identical tuba played the same tone while at rest in the railway station. Assume that the speed of sound in air was 343 m/s.

(a) If the train car approached the station at a speed of 20.0 m/s, at what frequency did the observers in the station perceive the sound from the tuba on train car?

/2

(b) What beat frequency was heard by observers in the railway station if the train car approached the station at a speed of 20.0 m/s?

/2

(c) What beat frequency was heard by observers on the train car, if it drove *away* from the station at a speed of 20.0 m/s?

/4