PHY2048 Physics with Calculus I

Section 611806

Prof. Douglas H. Laurence

Exam 2 (Chapters 5 − 8)

April 8, 2019

Name: _____

Instructions:

This exam is composed of **10 multiple choice questions** and **4 free-response problems**. To receive a perfect score (100) on this exam, 3 of the 4 free-response problems must be completed. The fifth free-response problem **may <u>not</u> be answered for extra credit**. Each multiple choice question is worth 2.5 points, for a total of 25 points, and each free-response problem is worth 25 points, for a total of 75 points. This means that your exam will be scored out of 100 total points, which will be presented in the rubric below. **Please do not write in the rubric below; it is for grading purposes only.**

Only scientific calculators are allowed – do not use any graphing or programmable calculators.

For multiple choice questions, no work must be shown to justify your answer and no partial credit will be given for any work. However, for the free response questions, **work must be shown to justify your answers.** The clearer the logic and presentation of your work, the easier it will be for the instructor to follow your logic and assign partial credit accordingly.

The exam begins on the next page. **The formula sheet is attached to the end of the exam.**

Exam Grade:

Multiple Choice	
Problem 1	
Problem 2	
Problem 3	
Problem 4	
Total	

MULTIPLE CHOICE QUESTIONS

1. A 4.9kg mass is initially at rest on a surface with $\mu_s = 0.55$ and $\mu_k = 0.45$. A 30N force is then applied to the mass. What is the following magnitude, and type, of friction acting on the mass?

   (a) 27N, static

   (b) 30N, static

   (c) 22N, kinetic

   (d) 30N, kinetic

2. Box B is placed on top of box A. If box A is pushed to the right such that box boxes accelerate together, is there a friction on box B?

   (a) There is a kinetic friction, to the right

   (b) There is a static friction, to the right

   (c) There is a static friction, to the left

   (d) There is no friction on box B because it isn't sliding

3. Under what conditions is the energy of an object conserved?

   (a) If only gravity and the normal force act on an object

   (b) If only conservative forces act on an object

   (c) If the work due to non-conservative forces acting on the object is zero

   (d) Energy is a conserved quantity, so it's always conserved

4. A rope pulls a box upward with some force, at a constant velocity. During this lift, the energy of the box is conserved.

   (a) True

   (b) False

5. A 1kg ball is held against a horizontal, 50 N/m spring compressed by 12cm. If the spring is released, at what speed would the ball travel at when it leaves the spring?

   (a) 0.85 m/s

   (b) 1.70 m/s

   (c) 2.50 m/s

   (d) 3.14 m/s

6. A mass slides up an incline under the influence of friction, at a constant velocity. The total work done on this mass should be:

   (a) Positive

   (b) Negative

   (c) Zero

   (d) Impossible to tell without numbers

7. A 2.5kg ball bounces off a wall horizontally. The ball hits the wall at 12 m/s, and leaves the wall at 7 m/s. If the collision takes 1.5 ms, what is the average force of the wall on the ball?

   (a) 8,333 N

   (b) 10,666 N

   (c) 20,333 N

   (d) 31,666 N

8. Which of the following is an important consequence of Newton's third law?

   (a) An object's momentum will only change if a force acts upon it

   (b) The net internal force on any system is always zero

   (c) The net external force on any system is always zero

   (d) Momentum is always conserved

9. When is the momentum of a system conserved?

   (a) Momentum is a conserved quantity, so it's always conserved

   (b) Only during collisions

   (c) Only if the net internal force on the system is zero

   (d) Only if the net external force on the system is zero

10. Initially, a 75g piece of clay rolls at 15 cm/s to the right, while an 50g piece of clay rolls at 20 cm/s to the left. During the collision, the two pieces of clay stick together. After the collision, in what direction does the lump of clay move?

    (a) To the left

    (b) To the right

    (c) It's stopped by the collision

    (d) None of the above

FREE-RESPONSE PROBLEMS

1. A 2kg box, box B, is placed on top of a 5kg box, box A. Between the box A and the ground are the coefficients $\mu_{s1} = 0.5$ and $\mu_{k1} = 0.4$, and between the box B and box A is the coefficient $\mu_{s2} = 0.6$.

a) If box A is pushed by a horizontal, 20N force, is there any friction acting on box B? If so, what type and what magnitude?

b) If box A is pushed by a horizontal, 50N force, is there any friction acting on box B? If so, what type and what magnitude?

c) What is the maximum horizontal force that can be applied on box A before box B slips off of box A?

2. A 1.2kg ball of clay rolls down a ramp from a height of 15cm. At the bottom of the ramp, it collides with a second ball of clay, of mass 2.5kg, causing them to stick together.

a) At the bottom of the ramp, what is the speed of the 1.2kg ball of clay?

b) After they collide, what is the speed of the combined lump of clay?

c) Is energy conserved throughout this entire process? If not, how much energy is lost from start to finish?

3. A horizontal spring, of force constant 200 N/m, is placed in front of a ramp, such that a 175g plastic ball can be propelled by the spring and roll up the ramp. Before the ball is fired, the spring is compressed by 10cm.

a) Ignoring any friction or air resistance, how fast is the plastic ball fired from the spring?

b) If friction does -0.15J of work while the ball rises up the ramp, what is the maximum height the ball will roll up the ramp to?

c) If friction does the same amount of work on the way down, and the ball hits the spring again at the bottom of the ramp, how far will the ball compress the spring when it returns?

4. A 1200kg car, moving at 25 m/s to the right, collides with a 2500kg truck, moving at 15 m/s to the left.

   a) If the car recoils at 15 m/s to the left, what is the final speed and direction of the truck?

   b) If the collision between the car and truck is perfectly inelastic, what is the final speed and direction of each object?

   c) If the collision is elastic, what is the final speed and direction of each object?

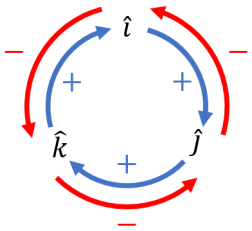
   d) What is the maximum amount of heat that can be released during a collision between these two objects?

FORMULA SHEET

- Vectors:

$$\begin{aligned}\vec{A}\cdot\vec{B} &= AB\cos\theta \\ &= A_xB_x + A_yB_y + A_zB_z\end{aligned}$$

$$\left|\vec{A}\times\vec{B}\right| = AB\sin\theta$$



- Kinematics:

$$g = 9.8\text{m/s}^2$$

$$\vec{v}_{av} = \frac{\Delta\vec{x}}{\Delta t}$$

$$\vec{a}_{av} = \frac{\Delta\vec{v}}{\Delta t}$$

$$\Delta x = v_0t + \frac{1}{2}at^2$$

$$v = v_0 + at$$

$$v^2 = v_0^2 + 2a\Delta x$$

- Forces:

$$\sum\vec{F} = m\vec{a}$$

$$W = mg$$

$$f_{s,max} = \mu_sN$$

$$f_k = \mu_kN$$

- Work & Energy:

$$W = \vec{F} \cdot \Delta\vec{x} \quad \text{or} \quad W = \int \vec{F} \cdot d\vec{x}$$

$$W_{tot} = \Delta K$$

$$W_{cons} = -\Delta U$$

$$W_{nc} = \Delta E$$

$$K = \frac{1}{2}mv^2$$

$$U_g = mgy$$

$$U_{sp} = \frac{1}{2}kx^2$$

$$K_i + U_i = K_f + U_f \quad \text{(energy conservation)}$$

$$K_i + U_i + W_{nc} = K_f + U_f \quad \text{(general energy equation)}$$

- Momentum & Collisions:

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

$$J = \Delta\vec{p} = \int \vec{F} dt \quad \text{(impulse)}$$

$$\sum \vec{F} = \frac{d\vec{p}}{dt} \quad or \quad \sum \vec{F}_{av} = \frac{\Delta\vec{p}}{\Delta t}$$

$$m_1\vec{v}_{1i} + m_2\vec{v}_{2i} = m_1\vec{v}_{1f} + m_2\vec{v}_{2f}$$

$$m_1\vec{v}_{1i} + m_2\vec{v}_{2i} = (m_1 + m_2)\vec{v}_f \quad \text{(when objects stick together)}$$

$$\vec{v}_{1i} + \vec{v}_{1f} = \vec{v}_{2i} + \vec{v}_{2f} \quad \text{(elastic collisions)}$$