Family Name, Given Name (Please print) | Student Number | UofT Email address

UNIVERSITY OF TORONTO

FACULTY OF APPLIED SCIENCES & ENGINEERING

FINAL EXAMINATION: December 19 , 2022

DURATION: 2.5 hours

PHY180 – Foundations of Physics

Calculator Type: 2

Examiner: William Trischuk

PLEASE read carefully the following instructions.

There are eight (8) questions on this final exam. Your best seven (7) answers will contribute **equally** to the final grade of the exam. You do not have to choose (or indicate) which seven questions you want to count. If in doubt, complete all eight questions – all will be graded and the highest seven marks will count towards your score on the final exam

Before starting, please **print** your name, student number, and your UofT email address **on the front of this test paper**. Answer all questions on the test paper. Your completed test papers will be scanned, graded electronically. if you need more space you can continue your answer on the **back** of the page.

To get full credit you must show intermediate steps in your solutions. Partial credit will be given for partially correct answers, so show any intermediate calculations that you do and write down, **in a clear fashion** any relevant assumptions you are making along the way.

Do not separate the sheets of the question paper. **Hand in all pages where you will have written your answers, at the end of the exam. If you need extra space you can continue your answers on the back of the page.**

Good luck!

1. You jump on your bicycle, ride at a constant acceleration of 0.80 m/s^2 for 30s, and then continue riding at a constant velocity for 500 m. You then slow to a stop, with a constant acceleration over 20 m.

    a) What is the total distance you travel during this ride?

    b) How long does the ride take?

    c) What is your average speed for this trip?.

2. Object A has an inertia of 2 kg and object B has an inertia of 1 kg. They approach each other with a relative speed of 2 m/s and collide elastically. For each object, sketch the velocity-versus-time graph for the interval starting a few seconds before the collision and ending a few seconds after the collision. You should sketch the answers for each part (a) thru c)) on a single graph (ie. both object A and B on the same graph). To get full credit you should clearly indicate the absolute speed of each object before and after the collision.

   a) Do this for the reference frame where A is originally at rest;

   b) Repeat the sketch for the reference frame where B is originally at rest;

   c) Finally, make the sketch for the zero-momentum reference frame.

3. A 2.4 kg ball is dropped from a height of 10 m onto the ground. The ball bounces back up to a height of 8.0 m.

   a) What is the impulse delivered to the ball by the ground?

   b) What is the coefficient of restitution of the collision?

4. A wagon is coasting along a level sidewalk at 5.00 m/s. It's wheels have very good bearings so it will continue at this speed as long as nothing interacts with it. You are standing on a platform next to the sidewalk and you drop vertically on to the wagon as it passed by. The wagon has an inertia of 35.0 kg, and you have an inertia of 70.0 kg. We discussed an example very similar to this in class.

   a) Use conservation of momentum to determine the speed of the wagon after you are in it.
   b) Use conservation of energy to determine that speed.
   c) If you've done parts a) and b) correctly you should see a difference in your answers. Why? Which method is correct?

5. A team of dogs accelerates a 100 kg dogsled from 0 to 5.0 m/s in 3.0 s. To answer the following questions you can assume that the acceleration of the sled is constant and neglect any friction between the sled and snow.

   a) What is the magnitude of the force exerted by the dogs on the sled?

   b) What is the work done by the dogs on the sled in the 3.0 s ?

   c) What is the instantaneous power of the dogs at the end of the 3.0 s?

   d) What is their instantaneous power at $t = 1.5$ s?

6. A package is dropped by an Amazon delivery drone traveling at 25 m/s (horizontally) from an altitude of 350 m. Unfortunately, the parachute on the package fails to open. To answer the following questions you should neglect air resistance.

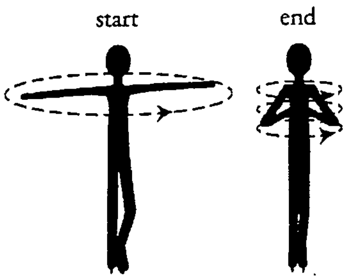
    a) Why do you not need to know the mass of the package, to answer parts b) thru d)?

    b) How long does it take for the package to hit the ground?

    c) How far does the package travel, horizontally, from the point it was dropped, before it hits the ground?

    d) What is the speed of the package just before it hits the ground?

7. A figure skater starts out spinning at 1.3 revolutions per second with his arms out-stretched, as shown in the figure. He wears weighted bracelets to enhance the spin-up effect that occurs when he pulls his arms in nearer his body.



a) Calculate his final rotational speed if his rotational inertia decreases from 3.6 $kg \cdot m^2$ to 1.2 $kg \cdot m^2$ when he pulls his arms in closer to his body (seen the 'end' figure in the sketch).

b) Determine the increase in his rotational kinetic energy.

c) Where does this added energy come from?

8. A 4.0 kg object is suspended from the ceiling by a spring and undergoes simple harmonic motion with an amplitude of 0.75 m. At the highest point in the motion, the spring is at the length that would be its relaxed length if the 4.0 kg object was not attached. To solve the rest of this problem you can set the total energy of the system to 0 J at this highest point.

   a) Why does it not matter what specific value of the total energy you choose at the highest point?

   For the object at each of three positions: its lowest position; it's equilibrium position; and it's highest position, calculate:

   b) the elastic potential energy of the spring;
   c) the kinetic energy of the 4.0 kg object;
   d) the gravitational potential energy of the Earth/object system.
   e) How does the sum of these three energies (in each of the three positions) relate to the initial energy given in the statement of the problem.