PHY2053 General Physics I

Section 584771

Prof. Douglas H. Laurence

Final Exam

May 3, 2018

Name: ______________________________

Instructions:

This final exam is **a take home exam**. It will be posted online sometime around **noon of the exam date** and is **due at midnight of the exam date**. Be aware that **late submissions will not be accepted**! You will have roughly 12 hours to complete the exam and then **email it back to me**, so that I have a record of the time it was submitted. The submission can be typed, scanned, or (worse case scenario) **clear** photographs of your work can be submitted.

This exam is composed of **10 multiple choice questions** and **5 free-response problems**. To receive a perfect score (100) on this exam, 4 of the 5 free-response problems must be completed. The fifth free-response problem **may not be answered for extra credit**. Each multiple choice question is worth 2 points, for a total of 20 points, and each free-response problem is worth 20 points, for a total of 80 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	
Problem 5	
Total	

MULTIPLE CHOICE QUESTIONS

1. A basketball player is running "suicide sprints," which involve sprinting from one line to another line 40m away, turning around quickly, and sprinting back to the starting line. If the player can cover each of the 40m legs of the trip in 5s, what is his average velocity?

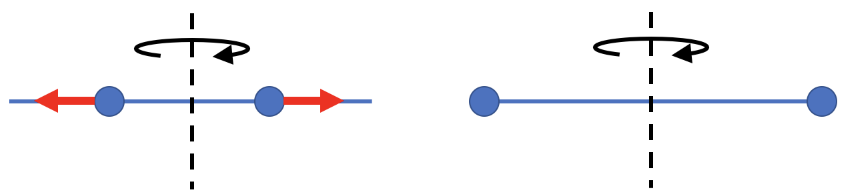
   (a) 0
   (b) 8 m/s
   (c) 40 m/s
   (d) 80 m/s

2. Box B sits at rest on top of Box A. If you push Box A, causing it to accelerate, and Box B moves along on top of Box A undisturbed. Does Box B feel a friction force?

   (a) No, because it's moving at a constant velocity
   (b) No, because it's accelerating
   (c) Yes, a static friction force
   (d) Yes, a kinetic friction force

3. You're trying to move a heavy object, with a mass of 100kg, along a floor with friction. The coefficients of friction between the object and the floor are $\mu_s = 0.45$ and $\mu_k = 0.35$. If you push on the object with a force of 600 N, what is the magnitude of the friction acting on the object?

   (a) 0N
   (b) 343N
   (c) 441N
   (d) 600N



4. A rod with two identical masses spins with some moment of inertia I, such that the masses are free to slide along the rod without friction. As the rod rotates, the masses slide out to the edge of the rod. As this is occurring, the moment of inertia I is:

   (a) Increasing
   (b) Not changing
   (c) Decreasing
   (d) None of the above

5. A pulley is composed of a rope wound around a cylinder; as the rope is pulled out, the cylinder rotates. If at the end of the rope, there is some mass, and releasing this mass causes the pulley to rotate, what force is putting a torque on the pulley?

   (a) There is no torque being put on the pulley
   (b) The tension in the rope
   (c) The weight of the mass
   (d) The weight of the pulley

6. A box is pushed along a path of some length, causing gravity to do work on the box. If the box were pushed along a path with a greater length, then:

   (a) Gravity would do more work, because it is conservative

   (b) Gravity would do more work, because it is non-conservative

   (c) Gravity would do the same work, because it is conservative

   (d) Gravity would do the same work, because it is non-conservative

7. Block A, with a mass of 0.25kg, moving at 20 m/s in the x-direction, collides with Block B, of mass 0.5kg, moving at 10 m/s in the $-x$-direction. If they collide such that they stick together after the collision, in what direction do they move after?

   (a) x-direction

   (b) $-x$-direction

   (c) y-direction

   (d) They don't move post-collision

8. A pendulum's bob (the mass at the end of the pendulum) is released from rest, at some angle. As it falls towards equilibrium, can you use kinematics to determine the bob's speed?

   (a) Yes, because acceleration is constant

   (b) Yes, because energy is conserved

   (c) No, because acceleration isn't constant

   (d) No, because energy is not conserved

9. Imagine some planet X existed, with a mass $M_X = 2M_E$ and a radius $R_X = R_E/\sqrt{2}$, where M_E and R_E are the mass and radius of the Earth, respectively. What would the gravitational acceleration be at the surface of X?

   (a) 2.45 m/s^2

   (b) 4.9 m/s^2

   (c) 19.6 m/s^2

   (d) 39.2 m/s^2

10. A man in a boat drops from peak to trough of the waves he is riding every 4s. What is the period of the water waves?

    (a) 2s

    (b) 4s

    (c) 8s

    (d) 12s

FREE-RESPONSE PROBLEMS

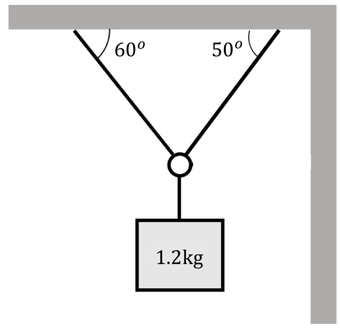
1. An object is dropped from the roof of a building of unknown height. Assume that $t = 0$ when the object is dropped.

(a) How far does the object drop from $t = 1.5s$ to $t = 2.7s$?

(b) If you placed a device to measure impact speed on the ground, and you measured an impact speed of 60m/s, how tall was the building?

(c) How long, then, did it take the object to hit the ground?

(d) If the building were four times as tall, what would the measured impact speed of the object be?



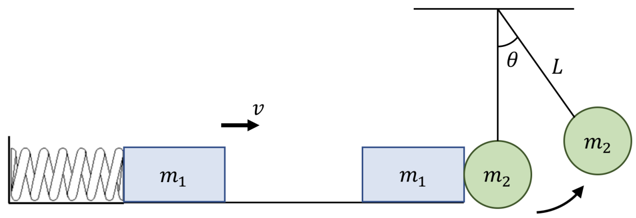
2. A 1.2kg mass hangs at rest from a ring, supported by two ropes, as shown in the figure above. Call the rope at a 60^o angle rope A and the rope at a 50^o angle rope B.

(a) Draw the free body diagram of the ring.

(b) Calculate the tension in rope A.

(c) Calculate the tension in rope B.

(d) Imagine if rope A was moved so that it was at a 90^o angle from the ceiling (straight up from the mass). What would the tension in rope B be in this case?

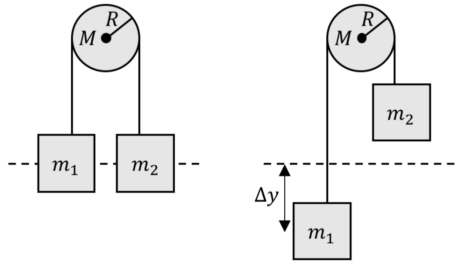


3. A block of mass $m_1 = 0.85$kg is pressed against a spring with a force constant $k = 150$ N/m, which is initially compressed by 20cm. When the spring is let go, it launches the mass at some speed v towards a pendulum, with a length $L = 100$cm and a mass $m_2 = 0.5$kg. After the block collides with the pendulum, m_2 rises to a maximum angle θ, as depicted in the above figure.

(a) At what speed v is the block launched from the spring?

(b) If the block and pendulum collide elastically, with what speed does the pendulum leave the collision?

(c) To what maximum angle θ does the pendulum rise?



4. Consider two masses, $m_1 = 1.5$kg and $m_2 = 0.6$kg, attached to the ends of a light rope wrapped around a solid cylinder of mass $M = 2.5$kg and radius $R = 17$cm, as shown in the figure above. m_1 and m_2 are released from rest and allowed to move such that m_1 drops a distance $\Delta y = 1.2$m.

(a) What is the final angular speed of the cylinder?

(b) How long did it take for m_1 to drop the 1.2m? *Hint: assume that acceleration is constant.*

(c) What was the net torque acting on the cylinder during this motion?

5. Halley's comet is a very famous comet in the sky that passes by Earth roughly every 75 years. In reality, Halley's comet has a fairly elliptical orbit, but for the purposes of this question, we'll consider the orbit to be circular. As a comet, it orbits the Sun, not the Earth. Note that $M_E = 5.97 \times 10^{24}$ kg, $R_E = 6400$ km, $M_S = 1.99 \times 10^{30}$ kg, $R_S = 700,000$ km, and the distance between the Earth and the Sun is 1.5×10^{11} m.

(a) What is the radius of the comet's orbit?

(b) What is the closest the comet gets to Earth?

(c) What is the angular speed of the comet?

(d) What is the angular acceleration of the comet?

FORMULA SHEET

- Constants:

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

- Vectors:

$$\begin{aligned} \vec{A} \cdot \vec{B} &= AB\cos\theta \\ &= A_x B_x + A_y B_y + A_z B_z \\ \left|\vec{A} \times \vec{B}\right| &= AB\sin\theta \end{aligned}$$

- Kinematics:

$$\Delta x = v_0 t + \frac{1}{2}at^2$$

$$v = v_0 + at$$

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

- Forces:

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

$$W = mg$$

$$f_{s,max} = \mu_s N$$

$$f_k = \mu_k N$$

- Work & Energy:

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

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

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

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

$$U_g = mgy$$

$$K_i + U_i + W_{nc} = K_f + U_f$$

$$\vec{F} = -\vec{\nabla}U$$

$$\vec{\nabla}f = \frac{\partial f}{\partial x}\hat{i} + \frac{\partial f}{\partial y}\hat{j} + \frac{\partial f}{\partial z}\hat{k}$$

- Momentum & Collisions:

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

$$\sum \vec{F} = \frac{d\vec{p}}{dt}$$

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

$$\vec{v}_{1i} - \vec{v}_{2i} = \vec{v}_{2f} - \vec{v}_{1f}$$

- Rotational Mechanics

$$\Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\omega = \omega_0 + \alpha t$$

$$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$$

$$s = r\theta$$

$$v = r\omega$$

$$a = r\alpha$$

$$\tau = rF\sin\theta$$

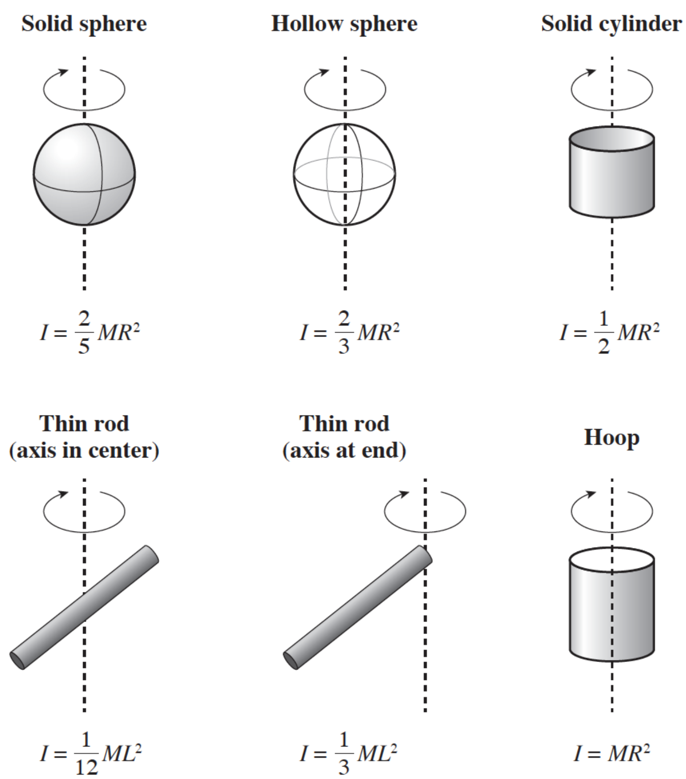
$$\sum \tau = I\alpha \quad \text{or} \quad \sum \tau = \frac{dL}{dt}$$

$$K_{rot} = \frac{1}{2}I\omega^2$$

$$L = I\omega \quad \text{or} \quad L = rp$$

$$I = \int r^2 dm$$

$$I_{new} = I_{cm} + md^2$$



- Gravity:

$$M_{Earth} = 5.97 \times 10^{24} \text{ kg}$$
$$M_{Sun} = 1.99 \times 10^{30} \text{ kg}$$
$$R_{Earth} = 6400 \text{ km}$$
$$G = 6.67 \times 10^{-11} \ \frac{\text{N}m^2}{\text{kg}^2}$$
$$F_G = G\frac{mM}{r^2}$$
$$a_G = G\frac{M}{r^2}$$
$$U_G = -G\frac{mM}{r}$$
$$v_{esc} = \sqrt{\frac{2GM}{R}}$$
$$v_{orb} = r\omega_{orb} = \frac{2\pi r}{T_{orb}}$$

- Oscillations:

$$F_{sp} = kx$$
$$U_{sp} = \frac{1}{2}kx^2$$
$$\omega_{sp} = \sqrt{\frac{k}{m}}$$
$$\omega_{pend} = \sqrt{\frac{g}{l}}$$
$$f = 1/T$$
$$\omega = 2\pi f$$

- Waves:

$$v = \lambda f$$
$$f_{beat} = |f_1 - f_2|$$

- Ideal Gases:

$$k_B = 1.38 \times 10^{-23} \text{ J/K}$$
$$R = 8.314 \text{ J/mol}\cdot\text{K}$$
$$N_A = 6.022 \times 10^{23} \text{ particles/mol}$$
$$K_{av} = \frac{3}{2}k_B T$$
$$PV = Nk_B T$$
$$v_{rms} = \sqrt{(v^2)_{av}}$$
$$T_K = T_{^\circ C} + 273$$