PHYS 110 Midterm 2 example – Spring 2022

Version A

Instructors: Dr. M. Laidlaw
Dr. T. Martin

Time Allowed: 90 minutes

Name: ______________________________

Student Number: ______________________________

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Read these instructions before starting the exam:

You must fill in your name and student number on the multiple choice form, answer your questions on the multiple choice form provided, and encode your test version correctly with the first question, or you will be assigned a score of 0.

This exam consists of 6 sequentially numbered pages, including the cover page (this one)

This exam consists of 21 questions, which are to be answered on the multiple choice answer forms provided. All questions are marked. The maximum score 20 marks. Indicate your answers on both the exam sheet and the multiple choice answer form; follow the instructions on the multiple choice answer form carefully. In the event that the answer you obtain is not one of the available choices, choose the closest one.

At the end of the exam, you must return both your answer sheet and this exam paper. Your name and student number must be on both.

You may bring into the exam *one* sheet of formulæ, constants, and similar information that you have prepared yourself. The sheet may be both sides of an 8.5" × 11" piece of paper. It should be hand-written.

You may bring into the exam a non-programmable, non-graphing calculator. As indicated in the syllabus: *the only acceptable calculators are the Sharp EL-510R series.*

Students who make use of unauthorized materials, communicate with each other during the exam, or appear to engage in similar dishonest practices may be dismissed from the exam and subject to further academic discipline.

You may find the following useful:

$$\begin{aligned}
ax^2+bx+c=0 \quad &\rightarrow \quad x=\frac{-b\pm\sqrt{b^2-4ac}}{2a}\\
\cos(90-\theta) &= \sin\theta\\
\sin(180-\theta) &= \sin\theta\\
g &= 9.8\frac{m}{s^2}=9.8\frac{N}{kg}\\
\frac{1}{4\pi\epsilon_0}=k_e &= 9.00\times10^{9}\frac{Nm^2}{C^2}\\
G &= 6.67\times10^{-11}\frac{Nm^2}{kg^2}
\end{aligned}$$

Good Luck

1. This is test version 'A'. Put 'A' as the answer to this question.
   (a) A
   (b) B
   (c) C
   (d) D
   (e) E

Use the following information for questions 2 – 5:
A $5.0kg$ mass and an $8.0kg$ mass collide. Prior to the collision the velocity of the $5.0kg$ mass was $\vec{v}_{5i} = 4.0\frac{m}{s}\hat{\imath}$ and that of the $8.0kg$ mass was $\vec{v}_{8i} = 1.0\frac{m}{s}\hat{\imath} + 3.0\frac{m}{s}\hat{\jmath}$. After the collision the velocity of the $5.0kg$ mass is $\vec{v}_{5f} = 3.0\frac{m}{s}\hat{\jmath}$.

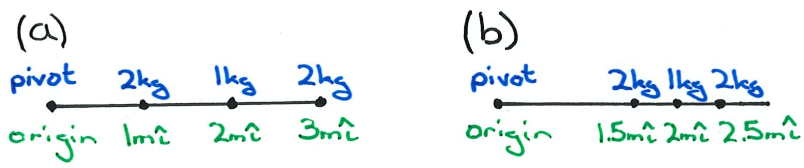
2. What is the total momentum immediately after the collision?
   (a) $8.0\frac{kg\ m}{s}\hat{\imath} + 9.0\frac{kg\ m}{s}\hat{\jmath}$
   (b) $8.0\frac{kg\ m}{s}\hat{\imath} + 24.0\frac{kg\ m}{s}\hat{\jmath}$
   (c) $15.0\frac{kg\ m}{s}\hat{\jmath}$
   (d) $20.0\frac{kg\ m}{s}\hat{\imath}$
   (e) *** $28.0\frac{kg\ m}{s}\hat{\imath} + 24.0\frac{kg\ m}{s}\hat{\jmath}$

3. What is the speed of the $8.0kg$ mass immediately after the collision? In other words, what is $|\vec{v}_{8f}|$?
   (a) $3.0\frac{m}{s}$
   (b) $3.2\frac{m}{s}$
   (c) $3.5\frac{m}{s}$
   (d) *** $3.7\frac{m}{s}$
   (e) $4.0\frac{m}{s}$

4. What angle relative to the x-axis (to $\hat{\imath}$) does the final momentum of the $8.0kg$ mass make?
   (a) *** $18°$
   (b) $37°$
   (c) $41°$
   (d) $49°$
   (e) $71°$

5. Assuming that the collision took $0.5s$ to occur, what is the magnitude of the average force on the $5.0kg$ mass? In other words, what is $\left|\vec{F}_{avg,5}\right|$?
   (a) $10N$
   (b) $13N$
   (c) $25N$
   (d) *** $50N$
   (e) $74N$

A $3.0m$ long massless rigid rod is initially held horizontally. There is a pivot at the left end of the rod, which is taken to be the origin. There are three masses, $2.0kg$, $1.0kg$, and $2.0kg$, which are located at $1.0m\hat{\imath}$, $2.0m\hat{\imath}$, and $3.0m\hat{\imath}$ respectively. They are attached to the rigid rod, as shown in 'a'.



6. What is the moment of inertia I measured around the pivot at the origin *as illustrated in diagram 'a'*?

   (a) $4.0kgm^2$
   (b) $5.0kgm^2$
   (c) $9.0kgm^2$
   (d) $20.0kgm^2$
   (e) *** $24.0kgm^2$

7. Suppose that the rod in diagram 'a' is released from the horizontal position described and allowed to rotate around the pivot located at the origin. What is the magnitude of the angular acceleration (α or $\frac{d^2\phi}{dt^2}$)it will experience at the instant it is released?

   (a) $0.4\frac{rad}{s^2}$
   (b) $2.0\frac{rad}{s^2}$
   (c) *** $4.1\frac{rad}{s^2}$
   (d) $10.8\frac{rad}{s^2}$
   (e) $19.6\frac{rad}{s^2}$

8. At the instant that the rod is released from the horizontal position and allowed to rotate, which best describes the magnitude of the force exerted by the pivot? *Hint: the center of mass accelerates downwards.*

   (a) $\left|\vec{F}_{pivot}\right| = 0N$
   (b) *** $\left|\vec{F}_{pivot}\right| = 8N$
   (c) $\left|\vec{F}_{pivot}\right| = 29N$
   (d) $\left|\vec{F}_{pivot}\right| = 49N$
   (e) $\left|\vec{F}_{pivot}\right|$ cannot be determined.

9. Suppose that there was a second $3.0m$ long rigid rod, also pivoted at the left end, with masses $2.0kg$, $1.0kg$, and $2.0kg$ at positions $1.5m\hat{\imath}$, $2.0m\hat{\imath}$, and $2.5m\hat{\imath}$ respectively. This is shown in 'b'. For rod 'b' which would be true?

   (a) *** $\frac{d^2\phi}{dt^2}$ would be bigger and $\left|\vec{F}_{pivot}\right|$ would be smaller.
   (b) $\frac{d^2\phi}{dt^2}$ would be bigger and $\left|\vec{F}_{pivot}\right|$ would be unchanged.
   (c) $\frac{d^2\phi}{dt^2}$ would be bigger and $\left|\vec{F}_{pivot}\right|$ would be bigger.
   (d) $\frac{d^2\phi}{dt^2}$ would be smaller and $\left|\vec{F}_{pivot}\right|$ would be smaller.
   (e) $\frac{d^2\phi}{dt^2}$ would be bigger and $\left|\vec{F}_{pivot}\right|$ would be unchanged.

Use the following information for questions 10 and 11:
A $40kg$ mass is at $1.0m\hat{\imath} + 4.0m\hat{\jmath}$, a $50kg$ mass is at $4.0m\hat{\imath}$, and a $10kg$ mass is at $1.0m\hat{\imath}$.

10. What is the gravitational force exerted on the $50kg$ mass by the $40kg$ mass?

    (a) $-1.9 \times 10^{-9}N\hat{\imath} + 2.5 \times 10^{-9}N\hat{\jmath}$
    (b) $-2.8 \times 10^{-9}N\hat{\imath} + 3.6 \times 10^{-9}N\hat{\jmath}$
    (c) *** $-3.2 \times 10^{-9}N\hat{\imath} + 4.3 \times 10^{-9}N\hat{\jmath}$
    (d) $-4.6 \times 10^{-9}N\hat{\imath} + 2.7 \times 10^{-9}N\hat{\jmath}$
    (e) $-1.4 \times 10^{-8}N\hat{\imath} + 8.3 \times 10^{-9}N\hat{\jmath}$

11. What is the magnitude of the net force exerted on the $50kg$ mass by both $10kg$ and $40kg$ masses?

    (a) $1.6 \times 10^{-9}N$
    (b) $3.7 \times 10^{-9}N$
    (c) $5.3 \times 10^{-9}N$
    (d) *** $8.1 \times 10^{-9}N$
    (e) $9.1 \times 10^{-9}N$

Use the following information for questions 12 – 14:
A $1.6 \times 10^{-26}kg$ ion carrying a charge $1.6 \times 10^{-19}C$ initially moves with a velocity of $1.5 \times 10^{3}\frac{m}{s}\hat{\imath} - 2.0 \times 10^{3}\frac{m}{s}\hat{k}$ in a region where the magnetic field $\vec{B} = 1.2T\hat{\jmath}$.

12. Suppose that at the instant described, the mass is at position $\vec{r} = 2.0m\hat{\imath}$. What is its angular momentum $\vec{L}$ measured about the origin?

    (a) $-1.6 \times 10^{-23}\frac{kg\ m}{s}\hat{\jmath}$
    (b) $-3.2 \times 10^{-23}\frac{kg\ m}{s}\hat{k}$
    (c) $4.8 \times 10^{-23}\frac{kg\ m}{s}\hat{\imath}$
    (d) *** $6.4 \times 10^{-23}\frac{kg\ m}{s}\hat{\jmath}$
    (e) $8.0 \times 10^{-23}\frac{kg\ m}{s}\hat{k}$

13. At the instant described, what is the *force* that the particle experiences?

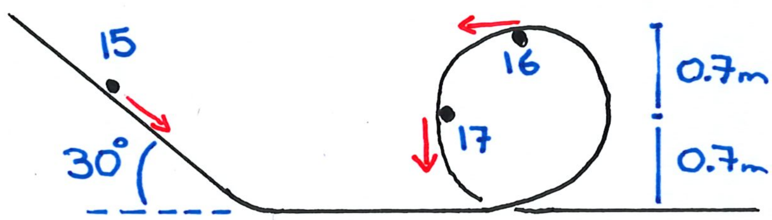
    (a) $-3.8 \times 10^{-16}N\hat{\imath} - 2.9 \times 10^{-16}N\hat{k}$
    (b) $-3.8 \times 10^{-16}N\hat{\imath} + 2.9 \times 10^{-16}N\hat{k}$
    (c) $4.8 \times 10^{-16}N\hat{\jmath}$
    (d) $3.8 \times 10^{-16}N\hat{\imath} - 2.9 \times 10^{-16}N\hat{k}$
    (e) *** $3.8 \times 10^{-16}N\hat{\imath} + 2.9 \times 10^{-16}N\hat{k}$

14. The particle is only subject to the Lorentz force, so it moves in a circle. What is the radius of that circle?

    (a) $1.2 \times 10^{-4}m$
    (b) $1.7 \times 10^{-4}m$
    (c) *** $2.1 \times 10^{-4}m$
    (d) $2.8 \times 10^{-4}m$
    (e) $3.5 \times 10^{-4}m$

Use the following information for questions 15 – 17:

A $5.0kg$ mass is on a rough slope which makes an angle of $30°$ with the horizontal. The coefficient of friction between the mass and the rough slope is 0.4. The mass is released, and begins to slide down the slope. At the bottom of the slope, it moves on a horizontal frictionless surface and then goes through a vertical loop of radius $0.7m$. This is shown in the diagram below.



15. What is the magnitude of the mass's acceleration while on the slope?

    (a) $1.0\frac{m}{s^2}$
    (b) *** $1.5\frac{m}{s^2}$
    (c) $4.6\frac{m}{s^2}$
    (d) $4.9\frac{m}{s^2}$
    (e) $6.5\frac{m}{s^2}$

16. If the mass is moving with a speed of $4.0\frac{m}{s}$ when at the top of the loop, what is the magnitude of the normal force it experiences?

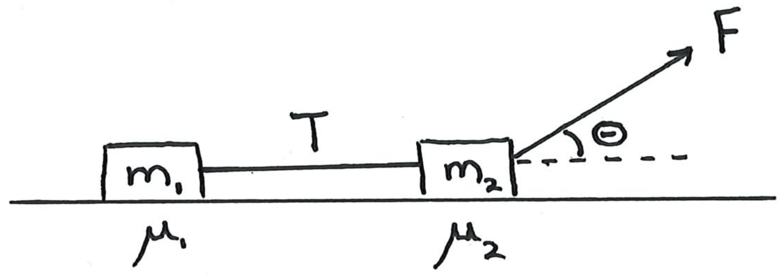
    (a) $49N$
    (b) $57N$
    (c) *** $65N$
    (d) $114N$
    (e) $163N$

17. When the mass has gone further around the loop, at the instant when its velocity is vertical, it is moving with a speed of $5.5\frac{m}{s}$. At this instant, what is the magnitude of the normal force it experiences?

    (a) $0N$
    (b) $49N$
    (c) $114N$
    (d) *** $216N$
    (e) $221N$

Use the following information for questions 18–21:

Two masses m_1 and m_2 are on a rough horizontal surface as shown. Their coefficients of kinetic friction with the surface are μ_1 and μ_2 respectively. The masses are connected by a horizontal rope which is under tension T. The second mass experiences a pulling force of magnitude F which makes an angle of θ above the horizontal.



18. The two masses both have the same acceleration $\vec{a} = a\hat{\imath}$. When you apply Newton's laws to the masses, what is the set of equations you obtain?

    (a) *** $m_1 a\hat{\imath} = (T - \mu_1 m_1 g)\,\hat{\imath}$ and $m_2 a\hat{\imath} = (F\cos\theta - T - \mu_2 m_2 g + \mu_2 F\sin\theta)\,\hat{\imath}$
    (b) $m_1 a\hat{\imath} = (T - \mu_1 m_1 g)\,\hat{\imath}$ and $m_2 a\hat{\imath} = (F\cos\theta - T - \mu_2 m_2 g)\,\hat{\imath}$
    (c) $m_1 a\hat{\imath} = (T - \mu_1 m_1 g)\,\hat{\imath}$ and $m_2 a\hat{\imath} = (F\cos\theta - T - \mu_2 m_2 g - \mu_2 F\sin\theta)\,\hat{\imath}$
    (d) $m_1 a\hat{\imath} = (T - \mu_1 m_1 g)\,\hat{\imath}$ and $m_2 a\hat{\imath} = (F\sin\theta - T - \mu_2 m_2 g + \mu_2 F\cos\theta)\,\hat{\imath}$
    (e) $m_1 a\hat{\imath} = (T - \mu_1 m_1 g)\,\hat{\imath}$ and $m_2 a\hat{\imath} = (F\sin\theta - T - \mu_2 m_2 g - \mu_2 F\cos\theta)\,\hat{\imath}$

19. What is the expression you obtain for the tension T of the rope expressed in terms of quantities given?

    (a) $\frac{m_1 m_2}{m_1+m_2}\left[\frac{F}{m_2}(\cos\theta - \mu_2\sin\theta) + (\mu_1 - \mu_2)\,g\right]$
    (b) *** $\frac{m_1 m_2}{m_1+m_2}\left[\frac{F}{m_2}(\cos\theta + \mu_2\sin\theta) + (\mu_1 - \mu_2)\,g\right]$
    (c) $\frac{m_1 m_2}{m_1+m_2}\left[\frac{F}{m_2}(\cos\theta - \mu_2\sin\theta) + (\mu_1 + \mu_2)\,g\right]$
    (d) $\frac{m_1 m_2}{m_1+m_2}\left[\frac{F}{m_2}(\cos\theta + \mu_2\sin\theta) + (\mu_1 + \mu_2)\,g\right]$
    (e) $\frac{m_1 m_2}{m_1-m_2}\left[\frac{F}{m_2}(\cos\theta - \mu_2\sin\theta) + (\mu_1 - \mu_2)\,g\right]$

20. What is the value of a for the case where $m_1 = 4.0kg$, $m_2 = 8.0kg$, $\mu_1 = \mu_2 = 0.3$, $F = 50N$, and $\theta = 15°$?

    (a) $0.8\frac{m}{s^2}$
    (b) $1.1\frac{m}{s^2}$
    (c) *** $1.4\frac{m}{s^2}$
    (d) $1.7\frac{m}{s^2}$
    (e) $2.0\frac{m}{s^2}$

21. What would happen to a and T if μ_2 were increased? *Assume the masses start from rest.*

    (a) T would increase and a would increase.
    (b) T would increase and a would decrease.
    (c) T would decrease and a would increase.
    (d) *** T would decrease and a would decrease.
    (e) T would be constant and a would decrease.

End of Exam