PHYS 110 Midterm 1 example – Spring 2022

Version A

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

Time Allowed: 90 minutes

Name: _____

Student Number: _____

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.

Prior to commencing the exam, you must count the sheets in your exam paper and immediately report any discrepancies to the invigilator.

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.

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

Consider the following four masses and location vectors:

$$\begin{aligned} m_1 &= 1.0kg \quad at \quad \vec{r}_1 = 1.0m\hat{\imath} + 2.0m\hat{\jmath} + 3.0m\hat{k} \\ m_2 &= 2.0kg \quad at \quad \vec{r}_2 = -2.0m\hat{\imath} + 1.0m\hat{\jmath} - 1.0m\hat{k} \\ m_3 &= 3.0kg \quad at \quad \vec{r}_3 = -1.0m\hat{\imath} - 2.0m\hat{\jmath} \\ m_4 &= 4.0kg \quad at \quad \vec{r}_4 = 2.0m\hat{\imath} - 1.0m\hat{\jmath} + 1.0m\hat{k} \end{aligned} \tag{1}$$

2. What is the x-component of the location of the center of mass of all four objects?

   (a) $-0.6m$
   (b) $0.0m$
   (c) *** $0.2m$
   (d) $0.3m$
   (e) $0.5m$

3. What is the angle between $\vec{r}_1$ and $\vec{r}_2$?

   (a) $19°$
   (b) $81°$
   (c) *** $109°$
   (d) $143°$
   (e) $161°$

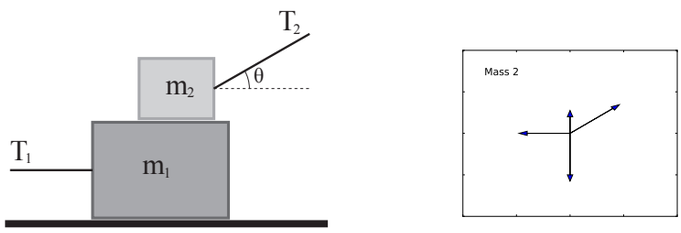
4. What is the y-component of $\vec{r}_1 \times \vec{r}_2$?

   (a) *** $-5m^2$
   (b) $-3m^2$
   (c) $-2m^2$
   (d) $2m^2$
   (e) $5m^2$

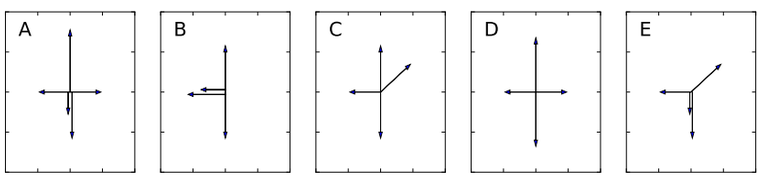
5. What is the magnitude of the angle between the vector from m_1 to m_4 and the vector along the positive z-axis (in other words: $\hat{k}$)?

   (a) $58°$
   (b) $74°$
   (c) $106°$
   (d) *** $122°$
   (e) It cannot be determined

A box of mass m_1 sits on the smooth (frictionless) ground. It is subject to a force of magnitude T_1 to the left being exerted by a horizontal rope. A box of mass m_2 is on top of the first box; this second box is subject to a force of magnitude T_2 up and to the right being exerted by another rope. The rope makes an angle θ with the horizontal, and the coefficient of static friction between the two boxes is μ. This is shown in the diagram below.



6. Given that the free-body diagram for mass m_2 is shown in the diagram above. Which of the options A–E is the best free-body diagram for m_1?



The answer is A.

7. What is the magnitude of the normal force the ground exerts on the box?

   (a) $m_1 g$
   (b) $m_1 g + m_2 g$
   (c) $m_1 g - T_2 \sin\theta$
   (d) $m_2 g - T_2 \sin\theta$
   (e) *** $m_1 g + m_2 g - T_2 \sin\theta$

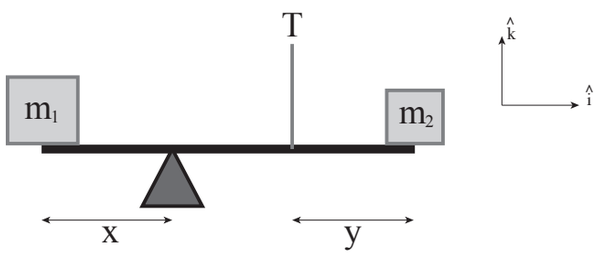
8. For the values $m_1 = 5kg$, $m_2 = 3kg$, $\mu = 0.6$, $\theta = 20°$, what best describes the values of T_2 which are consistent with equilibrium?

   (a) *** $T_2 \leq 15.4N$
   (b) $T_2 \leq 17.6N$
   (c) $T_2 \leq 18.7N$
   (d) $T_2 \leq 23.9N$
   (e) $T_2 \leq 29.4N$

9. Suppose that $T_2 = 20N$, $\theta = 37°$, $m_1 = 6kg$, $m_2 = 6kg$, and $\mu = 0.5$. What is the value of T_1 which is consistent with equilibrium?

   (a) *** $T_1 = 16N$
   (b) $T_1 = 23N$
   (c) $T_1 = 29N$
   (d) $T_1 = 53N$
   (e) $T_1 = 59N$

A massless rigid beam of length L is held horizontally in equilibrium by a rope and balanced on a pivot. The beam supports a mass m_1 at the left end, and a mass m_2 at the right end. The pivot is located a distance x from the left end of the beam, and the rope is attached a distance y from the right end of the beam. The pivot exerts a force $\vec{F}_p$ on the beam, and the rope pulls with a tension T directly upwards. This scenario is shown in the diagram.



10. What is $\vec{\tau}$ exerted by the rope as measured around the location of the pivot?

    (a) $(L-x)\,T$ out of the page
    (b) $(L-y)\,T$ out of the page
    (c) *** $(L-x-y)\,T$ out of the page
    (d) $(L-y)\,T$ into the page
    (e) $(L-x-y)\,T$ into of the page

11. Which expression is consistent with $\vec{\tau}_{net}=0$?

    (a) $m_1gx-m_2gy=0$
    (b) $-m_1gx+TL+m_2gy=0$
    (c) *** $-m_1gx-T\,(L-x-y)+m_2g\,(L-x)=0$
    (d) $m_1gx-m_2g\,(L-x)=0$
    (e) $-m_1gx+T\,(L-x-y)+m_2g\,(L-x)=0$

12. Which expression is consistent with $\vec{F}_{net}=0$?

    (a) $T-m_1g-m_2g=0$
    (b) $\left|\vec{F}_p\right|+m_1g+m_2g=0$
    (c) $\left|\vec{F}_p\right|-T+m_1g-m_2g=0$
    (d) *** $\left|\vec{F}_p\right|+T-m_1g-m_2g=0$
    (e) $\left|\vec{F}_p\right|-T=0$

13. If $m_1=4kg$, $m_2=6kg$, $x=\frac{L}{3}$, and $y=\frac{L}{3}$, what is $\left|\vec{F}_p\right|$?

    (a) *** $19.6N$
    (b) $29.4N$
    (c) $39.2N$
    (d) $49N$
    (e) $58.8N$

A mass is moving with constant acceleration. At time $t = 0s$ the mass's position is $-2m\hat{\imath}+1m\hat{\jmath}$. The mass's speed is $10\frac{m}{s}$ and the mass's direction of travel makes an angle of $-37°$ with the positive x-axis. The mass is subject to a constant acceleration of

$$\vec{a} = 3\left[\frac{m}{s^2}\right]\hat{\imath} + 3\left[\frac{m}{s^2}\right]\hat{\jmath}. \tag{2}$$

14. At time $t = 0s$ what is the velocity?

    (a) $6\left[\frac{m}{s}\right]\hat{\imath} + 8\left[\frac{m}{s}\right]\hat{\jmath}$
    (b) $8\left[\frac{m}{s}\right]\hat{\imath} + 6\left[\frac{m}{s}\right]\hat{\jmath}$
    (c) $10\left[\frac{m}{s}\right]\hat{\imath}$
    (d) *** $8\left[\frac{m}{s}\right]\hat{\imath} - 6\left[\frac{m}{s}\right]\hat{\jmath}$
    (e) $6\left[\frac{m}{s}\right]\hat{\imath} - 8\left[\frac{m}{s}\right]\hat{\jmath}$

15. At what time in the future will the x-component of the mass's position be $3m$?

    (a) $0.31s$
    (b) *** $0.57s$
    (c) $0.63s$
    (d) $4.3s$
    (e) $5.9s$

16. At the time $t = 2.0s$ what is the y-component of position?

    (a) $-11m$
    (b) *** $-5m$
    (c) $1m$
    (d) $14m$
    (e) $20m$

17. What condition would best describes the instant when the y-component of position is a minimum or maximum?

    (a) $x(t) = 0$
    (b) $y(t) = 0$
    (c) $\frac{d}{dt}x(t) = 0$
    (d) *** $\frac{d}{dt}y(t) = 0$
    (e) $\frac{d^2}{dt^2}x(t) = 0$

A particle's position as a function of time is given by

$$\vec{r}(t) = 2\,[m]\sin\left(\pi\left[\frac{rad}{s}\right]t\right)\hat{\imath} + \left(1\left[\frac{m}{s^3}\right]t^3 - 3\left[\frac{m}{s^2}\right]t^2\right)\hat{\jmath} \qquad (3)$$

18. What is the magnitude of the particle's velocity at $t = 2.0s$?

    (a) $2.0\frac{m}{s}$
    (b) $3.1\frac{m}{s}$
    (c) $4.2\frac{m}{s}$
    (d) ***$6.2\frac{m}{s}$
    (e) $7.4\frac{m}{s}$

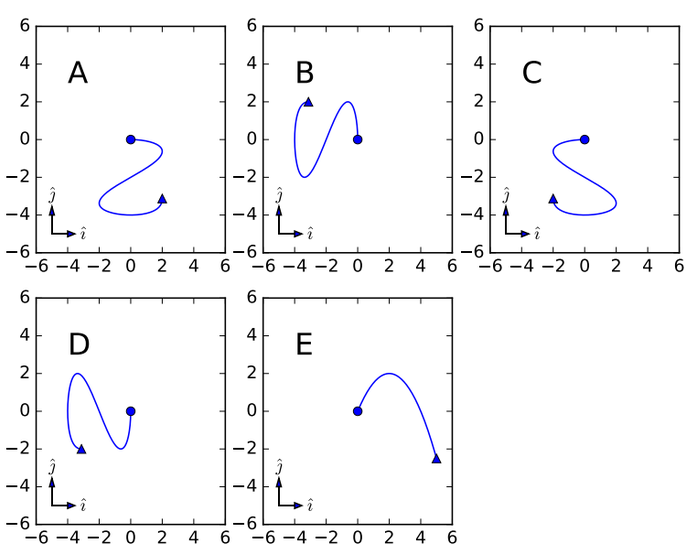
19. What is the magnitude of the particle's acceleration at $t = 3.5s$?

    (a) $6\frac{m}{s^2}$
    (b) $15\frac{m}{s^2}$
    (c) $20\frac{m}{s^2}$
    (d) *** $25\frac{m}{s^2}$
    (e) $35\frac{m}{s^2}$

20. Which unit vector best describes the particle's velocity at $t = 0s$?

    (a) *** $\hat{\imath}$
    (b) $-\hat{\imath}$
    (c) $\hat{\jmath}$
    (d) $-\hat{\jmath}$
    (e) $0.8\hat{\imath} + 0.6\hat{\jmath}$

21. Which of the following graphs best show the trajectory of the particle, starting at $t = 0s$ and ending at $t = 2.5s$? The trajectories are marked with a circle indicating the position at $t = 0s$ and a triangle indicating the position at $t = 2.5s$.



The answer is A.

End of Exam