Physics 206 – Comprehensive Exam

Spring 2023 (all UP sections)

28 April 2023

Answer Key

- There are **24** problems.
- You have **180 minutes** (3 hrs) to complete the exam.
- There is only one correct answer of the options given, but incorrect answers may yield some of the total LOs tested, a type of partial credit.
- **Multiple answers are not allowed**. If two or more bubbles are filled for a given question, you will receive a zero for that question – even if one is correct.
- There is **no penalty** for incorrect answers. So there is no harm in guessing if you can't solve the problem and/or run out of time.
- Have your **TAMU ID ready when submitting your Grading Sheet** to the proctor. You may keep the exam, any blank sheets you used to work out problems, and/or the formula sheet following submitting your grading sheet.
- Cell phone use during the exam is **strictly prohibited**. Please turn off all ringers as calls during an exam can be quite distracting.
- You are allowed to use a simple scientific calculator, but **graphing calculators are NOT allowed.**
- Take $g = 9.8\,m/s^2$ unless otherwise specified in the problem.

1) A 125 kg (including all the contents) rocket has an engine that produces a constant vertical force (called thrust) of 1720 N. Inside this rocket, a 15.5 N electrical power supply rests on the floor. Find the acceleration a of the rocket and the normal force N the floor applies on the power supply when it has reached an altitude of 120 m.

A) $a = 2.75\,m/s^2,\ N = 10.6$ N
B) $a = 2.75\,m/s^2,\ N = 13.9$ N
C) $a = 1.28\,m/s^2,\ N = 37.1$ N
D) $a = 1.28\,m/s^2,\ N = 32.9$ N
E) $a = 3.96\,m/s^2,\ N = 21.8$ N
F) $a = 3.96\,m/s^2,\ N = 28.5$ N

Answer LOs
A)
B)
C)
D)
E) 21, 22, 22, 23, 23, 26
F) 22,23

2) Two identical objects of mass m with the same initial velocities undergo two different motions; object A is thrown in the air at an angle θ whereas the other object B slides up a frictionless incline at the same angle θ (neglect air resistance).

I: Which object will reach a greater height (as measured from their corresponding initial positions)?
II: Which one will have a greater kinetic energy at the top?

A) I:A, II: A
B) I:A, II: B
C) I: B, II: A
D) I:B, II: B

Answer LOs
A) 12, 14, 34
B)
C) 12, 12, 14, 14, 34
D) 12, 14

3) A child throws a ball with an initial speed of 8.00 m/s at an angle of 40.0° above the horizontal. The ball leaves her hand 1.00 m above the ground and experience negligible air resistance. How far from where the child is standing does the ball hit the ground?

A) 7.47 m
B) 6.68 m
C) 5.67 m
D) 4.81 m
E) 3.73 m
Answer LOs
A) 1, 5, 12,13, 14, 14
B) 12, 13, 14, 14
C)
D)
E)

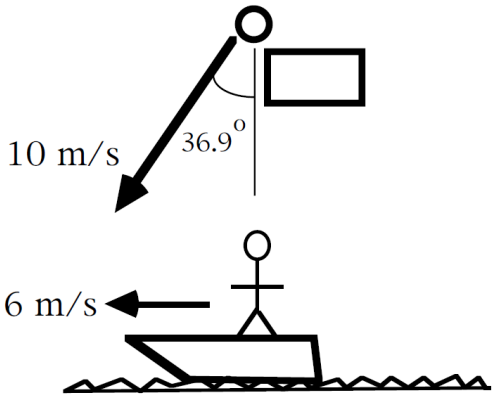
4) An aircraft performs a maneuver called an "aileron roll." During this maneuver, the plane turns like a screw as it maintains a straight flight path, which sets the wings in circular motion. If it takes 35 s to complete the circle and the *wingspan* of the plane is 11 m, what is the acceleration of the wing tip?

A) 0.36 m/s^2
B) 5.6 m/s^2
C) 1.0 m/s^2
D) 0.18 m/s^2
Answer LOs
A) 18, 19
B)
C)
D) 6, 18, 19

5) Two particles, A and B, are in uniform circular motion about a common center. The acceleration of particle A is 8.5 times that of particle B. The period of particle B is 2.0 times the period of particle A. The ratio of the radius of the motion of particle A to that of particle B is closest to

A) $r_A/r_B = 2.1$
B) $r_A/r_B = 4.3$
C) $r_A/r_B = 18$
D) $r_A/r_B = 0.24$
E) $r_A/r_B = 8.5$
Answer LOs
A) 4, 6, 19, 19
B)
C)
D)
E) 4, 19,19

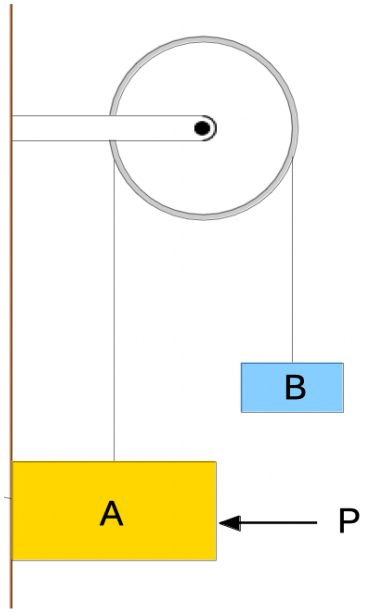
6) A rock is thrown downward from a bridge at an initial speed of 10 m/s and an angle of 36.9° from the vertical as shown in Figure. At the same instant a boat is passing under the bridge traveling 6 m/s in the direction shown. The horizontal and the vertical components (v_x, v_y) of the initial velocity of the rock *as seen by the person on the boat* are closest to



A) (6 m/s, 4 m/s)
B) (0, 8 m/s)
C) (2 m/s, 6 m/s)
D) (8 m/s, 6 m/s)

Answer LOs
A)
B) 1, 12, 13, 20
C) 12, 13, 20
D)

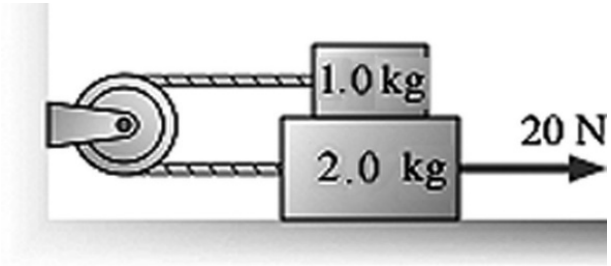
7) Block A of mass 8.0 kg and block B of unknown mass m_B are attached to a rope that passes over a *massless* and *frictionless* pulley. A 50 N horizontal force, P, pushes block A against a rough vertical wall as shown in Figure. The coefficients of static and kinetic frictions between the wall and block A are $\mu_s = 0.40$ and $\mu_k = 0.30$. Initially block B is held at rest. What are the smallest and largest masses of the block B that would keep the blocks from moving when block B is released? (take acceleration due to gravity $g = 10\,m/s^2$).



A) $4\,kg < m_B < 6\,kg$
B) $6\,kg < m_B < 10\,kg$
C) $8\,kg < m_B < 12\,kg$
D) $2\,kg < m_B < 6\,kg$
E) $10\,kg < m_B < 14\,kg$

Answer LOs
A) 23, 24, 27
B) 4, 6, 21, 21, 23, 24, 27, 29
C)
D)
E) 23, 24, 27

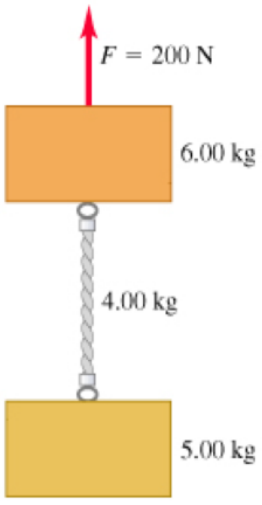
8) A force of 20 N is applied on the lower block as shown in Figure. The coefficient of kinetic friction between the lower block and the surface is 0.16. The coefficient of kinetic friction between the lower block and the upper block is also 0.16. The pulley has no appreciable mass or friction. What is the acceleration of the 2.0 kg block?



A) 4.1 m/s^2
B) 5.1 m/s^2
C) 8.4 m/s^2
D) 6.9 m/s^2
E) 7.6 m/s^2

Answer LOs
A) 4, 21, 23, 24, 28, 28
B)
C)
D) 21, 23, 28
E) 21, 23, 28

9) The two blocks are connected by a *heavy* uniform rope. What is the tension *in the middle of the rope?*



A) 66.7 N
B) 78.2 N
C) 93.3 N
D) 105.2 N
E) 118.7 N

Answer LOs
A) 21, 23
B)
C) 21, 23, 24
D)
E)

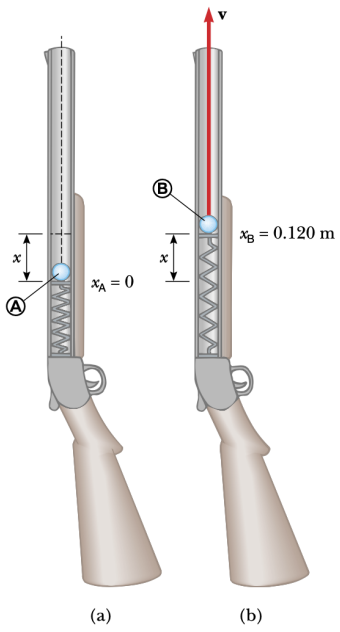
10) A 600-kg elevator *starts from rest.* It accelerates upward for 3.00 s until it reaches its cruising speed of 2 m/s. What is the average power P_{av} delivered to the elevator during this period and what is the instantaneous power of the *elevator motor* P when it moves at its constant cruising speed? (take acceleration due to gravity $g = 10\,m/s^2$)

A) $P_{av} = 100\,W, \quad P = 12000\,W$
B) $P_{av} = 500\,W, \quad P = 5000\,W$
C) $P_{av} = 100\,W, \quad P = 5000\,W$
D) $P_{av} = 400\,W, \quad P = 12000\,W$
E) $P_{av} = 400\,W, \quad P = 3000\,W$

Answer LOs
A) 21, 23, 33
B)
C)
D) 21, 23, 33, 33, 39
E) 33, 39

11) The launching mechanism of a toy gun consists of a spring of unknown spring constant k (see Figure). When the spring is compressed 0.120 m, the gun, when fired vertically, is able to launch a 0.0350-kg projectile to a maximum height of 20.0 m *above the position of the projectile before firing* (point A in the Figure). Neglecting all resistive forces, determine the spring constant k.

A) $k = 641$ N/m
B) $k = 953$ N/m
C) $k = 756$ N/m
D) $k = 476$ N/m
E) $k = 313$ N/m



Answer LOs
A)
B) 38, 38, 40
C)
D) 38, 40
E)

12) Find the (x, y) coordinates of the center of mass of the object shown in Figure, which consists of 4 uniform square sheets each having side length 2 m.

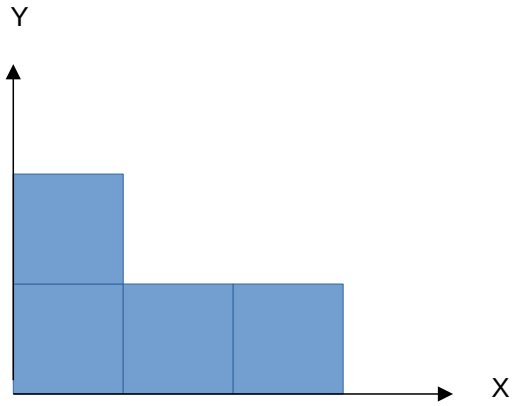
A) $\left(\frac{5}{2}, \frac{3}{2}\right)$ m

B) $\left(\frac{1}{2}, \frac{7}{2}\right)$ m

C) $\left(\frac{5}{3}, \frac{7}{3}\right)$ m

D) $\left(\frac{1}{3}, \frac{5}{3}\right)$ m

E) $\left(\frac{1}{2}, \frac{5}{3}\right)$ m



Answer LOs
A) 45
B)
C)
D)
E)

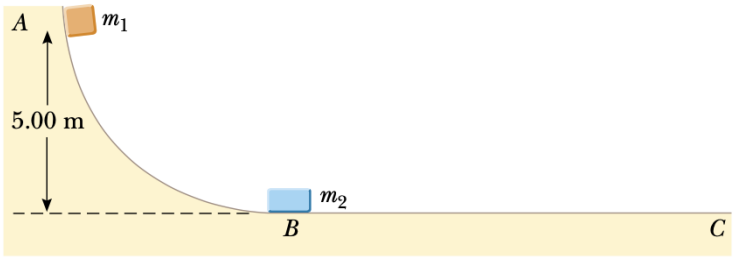
13) A tennis player receives a shot with the ball (0.02 kg) traveling horizontally at 60.0 m/s and *returns* the shot with the ball traveling horizontally at 40.0 m/s in the *opposite direction.* What is the impulse delivered to the ball by the racket?

A) 4 kg m/s
B) 0.3 kg m/s
C) 0.4 kg m/s
D) 6 kg m/s
E) 2 kg m/s
F) 0.6 kg m/s

Answer LOs
A)
B)
C) 46
D)
E) 46, 49
F)

14) Consider a frictionless track ABC as shown in Figure. A block of mass $m_1 = 2$ kg is released from A, 5.00 m above the ground. It then collides and sticks at B with a block of mass $m_2 = 8$ kg that is initially at rest. Calculate their common speed at the point C (take acceleration due to gravity $g = 10\,m/s^2$).

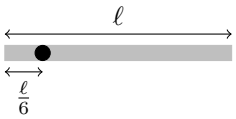
A) 10 m/s
B) 6 m/s
C) 2 m/s
D) 8 m/s
E) 4 m/s



Answer LOs
A) 34, 38, 40
B)
C) 34, 38, 40, 46, 48
D)
E)

15) A thin rod with length ℓ is held horizontally and then is released from rest. The rod is allowed to pivot freely about a point $\ell/6$ from the end as shown in the figure below. What is the angular acceleration of the rod the instant it is released?

A) $\frac{18}{7}\frac{g}{\ell}$
B) $\frac{12}{7}\frac{g}{\ell}$
C) $\frac{3}{2}\frac{g}{\ell}$
D) $\frac{18}{13}\frac{g}{\ell}$
E) $\frac{12}{13}\frac{g}{\ell}$



Answer LOs
A) 4, 52
B) 4, 52, 54, 55
C)
D)
E) 4, 54, 55

16) A uniform disk with a radius R and mass M is rotating about its center with an angular velocity of ω_0. A second disk with half the radius and the same mass is dropped from rest onto the rotating disk so that their centers are at the same position. After a short time they rotate together. What is the new angular velocity of the combined system?

A) $\frac{1}{4}\omega_0$
B) $\frac{1}{3}\omega_0$
C) $\frac{1}{2}\omega_0$
D) $\frac{2}{3}\omega_0$
E) $\frac{4}{5}\omega_0$

Answer LOs
A)
B)
C) 50, 53, 57, 59
D)
E) 50, 51, 53, 57, 59

17) Consider a system consisting of *point masses* in the (x, y) plane where there is a 5 kg mass at the position (0,2), a 10 kg mass at the position (2,2) and a 15 kg mass at the position (2,-1). What is the moment of inertia of this system about the axis of rotation given by the line $y = -2$?

A) 75 kg·m^2
B) 135 kg·m^2
C) 175 kg·m^2
D) 255 kg·m^2
E) 315 kg·m^2
Answer LOs
A)
B) 51
C)
D) 51, 53
E) 51

18) The position of a 6.0 kg mass that is in simple harmonic motion can be described by the formula $x(t) = 0.35\cos(4.0t - 0.85)$. What is the maximum kinetic energy of this mass?

A) 5.88 J
B) 1.47 J
C) 94.1 J
D) 0.368 J
E) 15.7 J
Answer LOs
A) 3, 34, 65
B) 34, 65
C)
D)
E)

19) In the previous problem, what is the force constant of the spring causing the mass to move in this way?

A) 96 N/m
B) 16 N/m
C) 24 N/m
D) 73 N/m
E) 5.9 N/m
Answer LOs
A) 65, 66
B)
C) 65
D)
E)

20) At a time defined to be $t = 0$, a tire is measured to be rotating at a rate of 10.0 rad/s. Due to frictional effects, the tire is going to slow down with a constant angular acceleration of 0.025 rad/s^2. How many revolutions does it complete before it comes to rest?

A) 2000
B) 155
C) 318
D) 68.0
E) 344

Answer LOs
A) 14, 15
B)
C) 10, 14, 15
D)
E)

21) A *hollow* sphere is *rolling without slipping* along flat ground when it reaches a hill with a maximum height of H above the ground. If it *continues to roll without slipping* up the hill, what velocity does the sphere need to have at the bottom so that it barely makes over the hill?

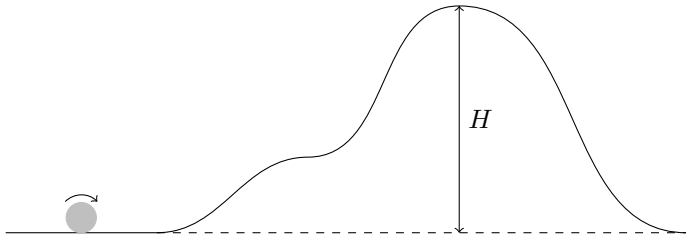
A) $\sqrt{\frac{6}{5}gH}$

B) $\sqrt{\frac{6}{7}gH}$

C) $\sqrt{\frac{4}{3}gH}$

D) $\sqrt{2gH}$

E) $\sqrt{3gH}$



Answer LOs

A) 6, 34, 35, 38, 40

B)

C)

D) 6, 34, 38, 40

E) 6, 35, 38, 40

22) A satellite is orbiting Mars at a height of 2000 km above the surface. Mars has a radius of 3390 km and a mass of 6.39×10^{23} kg. The satellite malfunctioned when it was moving with a speed of 2500 m/s and will unfortunately crash on the planet. Approximately how fast is it moving when it hits the surface? Ignore any atmospheric effects.

A) 3200 m/s

B) 4520 m/s

C) 6700 m/s

D) 7080 m/s

E) 3950 m/s

Answer LOs

A)

B)

C)

D)

E) 34, 40, 61

23) Astronomers have been observing a solar system and they have found a planet that is orbiting a star. The planet has a mass 4 times larger than the earth and it has a radius 3 times larger than earth. The star has 8 times more mass than our own and the orbital radius of the planet is 2 times larger than the earth's orbital radius. If a person weighs 150 pounds on earth, what would they weigh on this planet?

A) 66.7 pounds
B) 133 pounds
C) 150 pounds
D) 200 pounds
E) 300 pounds
Answer LOs
A) 3, 6, 60
B)
C)
D)
E)

24) How long does it take this planet to orbit its star?

A) 0.723 years
B) 1.00 years
C) 1.41 years
D) 1.84 years
E) 2.60 years
Answer LOs
A)
B) 63
C)
D)
E)