Physics 206 – Exam 3

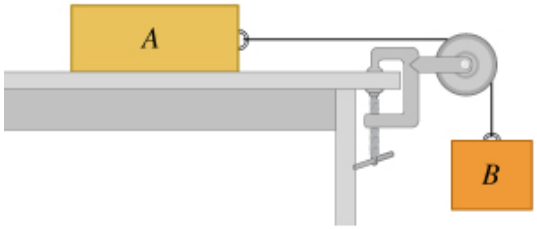
Spring 2023 (all UP sections)

17 April 2023

Answer Key

- There are **17** problems.
- You have **120 minutes** (2 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.**

1) Consider the system shown in the figure below. Block A has mass 4.00 kg, block B has mass 5.00 kg and the pulley is a solid disk of mass 2.00 kg and radius 10.0 cm. Assume the rope goes over the pulley without slipping and there is no friction between the block A and the table. If the system starts from rest, what is the speed of block B once it has fallen a distance of 1.50 m?



A) 4.04 m/s
B) 4.95 m/s
C) 3.56 m/s
D) 3.83 m/s
E) 3.24 m/s
F) 5.15 m/s

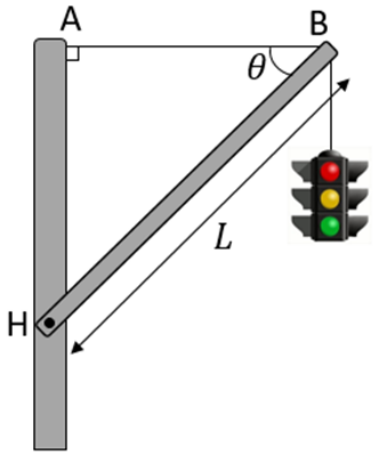
Answer LOs
A) 3, 34, 38, 40
B) 3, 35, 38, 40
C)
D) 3, 34, 35, 38, 40
E)
F)

2) Two masses ($m_A = 0.400$ kg, $m_B = 0.800$ kg) sitting on a *frictionless table* are pressed against opposite ends of a light spring of force constant 1.75 N/cm, compressing the spring by 0.250 cm from its normal length. What are the speeds of the two blocks once the spring is fully decompressed?

A) v_A=0.0640 m/s, v_B=0.0640 m/s
B) v_A=0.0427 m/s, v_B=0.0213 m/s
C) v_A=0.0427 m/s, v_B=0.0427 m/s
D) v_A=0.0213 m/s, v_B=0.0213 m/s
E) v_A=0.0302 m/s, v_B=0.0302 m/s
F) v_A=0.0201 m/s, v_B=0.0101 m/s
G) v_A=0.0101 m/s, v_B=0.0101 m/s
H) v_A=0.0201 m/s, v_B=0.0201 m/s

Answer LOs
A)
B) 4, 34, 38, 40, 46, 48
C) 34, 38, 40, 46, 48
D) 34, 38, 40, 46, 48
E) 34, 38, 40
F)
G)
H)

3) A traffic light, m, hangs from the end of long uniform pole of length L and mass M. The pole is held in place by a horizontal wire AB and a hinge H that are connected to a vertical support. The pole makes an angle $\theta = 37$ degrees with the horizontal wire. (Note that $\cos(37) = 4/5$ and $\sin(37) = 3/5$). What is the tension in the wire?



A) $\left(\frac{2}{3}M + \frac{4}{3}m\right)g$

B) $\left(\frac{4}{3}M + \frac{2}{3}m\right)g$

C) $\left(\frac{1}{2}M + m\right)g$

D) $\left(M + \frac{1}{2}m\right)g$

E) $\frac{4}{3}mg$

F) $\frac{4}{3}Mg$

G) mg

H) Mg

Answer LOs

A) 3, 21, 23, 24, 54

B) 21, 23, 24, 54

C) 21, 23, 24, 54

D)

E)

F)

G)

H)

4) Two objects have a 1D head-on collision. Object one has a mass m and velocity $2v$ to the right while object two has mass $4m$ and velocity v to the left. The final velocity of object two is $v/5$ to the right. Let the right be the positive direction. Determine the final velocity of object one and identify the type of collision.

A) $-\frac{14}{5}v$, elastic

B) $-\frac{14}{5}v$, inelastic

C) $+\frac{26}{5}v$, elastic

D) $+\frac{26}{5}v$, inelastic

E) $+\frac{17}{10}v$, elastic

F) $+\frac{17}{10}v$, inelastic

G) $-\frac{7}{10}v$, elastic

H) $-\frac{7}{10}v$, inelastic

Answer LOs

A) 3, 13, 46, 48, 50

B) 3, 13, 46, 48

C) 3, 46, 48

D) 3, 46, 48, 50

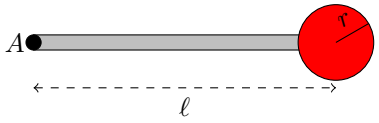
E) 13, 46, 48

F) 13, 46, 48, 50

G)

H)

5) In musical films, grumpy old men with canes will sometimes jump up and start dancing. A traditional cane consists of a thin long uniform slender rod of length ℓ with a small solid sphere of radius r stuck on the end *(the end of the rod extends into the center of the sphere).* Assume the rod and the sphere are of equal mass, m. What is the angular acceleration at the moment the system is released if it is free to rotate due to gravity around axis A which is coming out of the page as pictured below?



A) $\frac{3\ell g}{\frac{4}{3}\ell^2 + \frac{4}{5}r^2}$

B) $\frac{3\ell g}{\frac{2}{3}\ell^2 + \frac{4}{5}r^2}$

C) $\frac{3\ell g}{\frac{8}{3}\ell^2 + \frac{4}{5}r^2}$

D) $\frac{\ell g}{\frac{8}{3}\ell^2 + \frac{2}{5}r^2}$

E) $\frac{\ell g}{\frac{4}{3}\ell^2 + \frac{2}{5}r^2}$

F) $\frac{\ell g}{\frac{2}{3}\ell^2 + \frac{2}{5}r^2}$

G) $\frac{5\ell g}{\frac{4}{3}\ell^2 + \frac{4}{5}r^2}$

H) $\frac{5\ell g}{\frac{8}{3}\ell^2 + \frac{2}{5}r^2}$

Answer LOs

A)

B) 3, 21, 23, 53, 54, 55

C) 3, 21, 23, 52, 53, 54, 55

D)

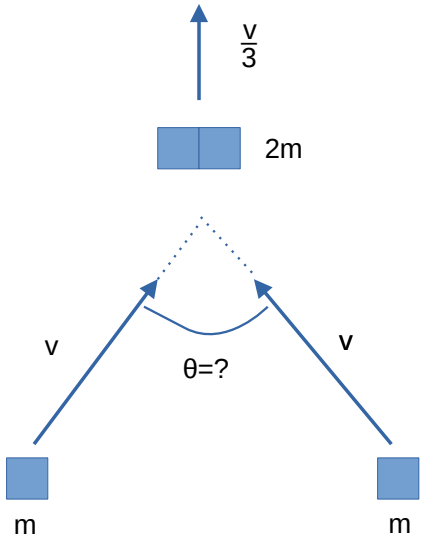
E) 21, 23, 52, 53, 54, 55

F) 21, 23, 53, 54, 55

G)

H)

6) After a collision between two objects of equal mass, each with the *same initial speed* v, the two objects move off *together* with speed $v/3$. What was the angle θ between their initial directions?



A) 70.5 degrees
B) 38.9 degrees
C) 19.5 degrees
D) 49.4 degrees
E) 24.7 degrees
F) 141.1 degrees
G) 114.4 degrees
H) 57.2 degrees

Answer LOs
A) 1, 2, 3, 46, 48
B) 1, 2, 6, 46, 48
C) 1, 2, 46, 48
D)
E)
F) 1, 2, 3, 6, 46, 48
G)
H)

7) What type of collision was the one in the previous problem?

A) Elastic
B) Inelastic
C) Completely inelastic

Answer LOs
A)
B)
C) 50

8) Block A has a mass m and moves to the *left* with a velocity of $2v$ along a smooth horizontal surface. A second block (Block B) of mass $3m$ slides on the same surface to the *right* with a velocity v. The blocks collide together in an *elastic collision*. Determine the final velocities of both blocks assuming the positive direction is to the right.

A) $v_{A,f} = -\frac{1}{2}v$, $v_{B,f} = +\frac{5}{2}v$

B) $v_{A,f} = +\frac{5}{2}v$, $v_{B,f} = -\frac{1}{2}v$

C) $v_{A,f} = -2v$, $v_{B,f} = +v$

D) $v_{A,f} = +v$, $v_{B,f} = -2v$

E) $v_{A,f} = -\frac{3}{4}$, $v_{B,f} = +3v$

F) $v_{A,f} = +3v$, $v_{B,f} = -\frac{3}{4}v$

G) $v_{A,f} = -\frac{7}{2}v$, $v_{B,f} = +\frac{3}{8}v$

H) $v_{A,f} = +\frac{3}{8}v$, $v_{B,f} = -\frac{7}{2}v$

Answer LOs

A) 34, 40, 46, 48, 50

B) 4, 34, 40, 46, 48, 50

C) 34, 40, 46, 48, 50

D)

E)

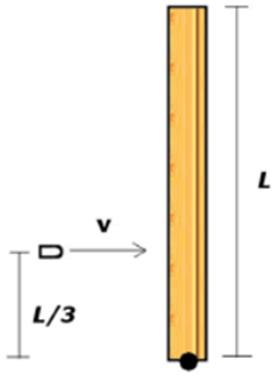
F)

G)

H)

9) A uniform long thin rod of length L and mass $2m$ is mounted vertically upward and hinged at the bottom of the rod. A bullet of mass m and velocity v strikes the rod a distance $L/3$ above the hinge. Once the bullet strikes the rod, it becomes embedded in it. What is the angular velocity ω of the system just after the collision?

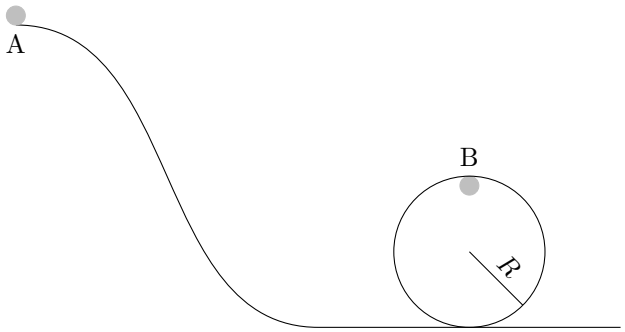
A) $\omega = \frac{1}{3}\frac{v}{L}$
B) $\omega = \frac{1}{2}\frac{v}{L}$
C) $\omega = \frac{5}{7}\frac{v}{L}$
D) $\omega = \frac{2}{3}\frac{v}{L}$
E) $\omega = \frac{3}{7}\frac{v}{L}$
F) $\omega = \frac{1}{4}\frac{v}{L}$
G) $\omega = \frac{8}{9}\frac{v}{L}$



Answer LOs
A) 50, 57
B) 50, 57, 57, 58, 59
C)
D)
E) 50, 51, 53, 57, 57, 58, 59
F)
G)

10) A solid sphere with a mass of 4.00 kg (and radius r) is released from rest at point A at the top of a track. As shown in the figure below, the bottom of the track is a circular loop with radius $R = 2.00$ m. The sphere *rolls without slipping* and reaches the point B where it barely touches the top of the vertical loop, so that the normal force exerted by the loop on the sphere at point B is zero. The kinetic energy of the sphere at point B is closest to:

A) 10.6 J
B) 15.7 J
C) 25.7 J
D) 39.2 J
E) 54.9 J
F) 75.3 J



Answer LOs
A)
B)4, 21, 23, 35
C)
D) 4, 21, 23, 34
E) 4, 21, 23, 34, 35
F)

11) An object's angular velocity (in SI units) can be defined by the formula $\omega(t) = (-6.0\,t^2 + 18)$ rad/s. The net torque on this object at the time $t = -2.0$ s is 1560 Nm, what is the moment of inertia of the object?

A) 492 kg m^2
B) 260 kg m^2
C) 190 kg m^2
D) 91 kg m^2
E) 78 kg m^2
F) 65 kg m^2

Answer LOs
A)
B) 55
C)
D)
E) 55
F) 8, 55

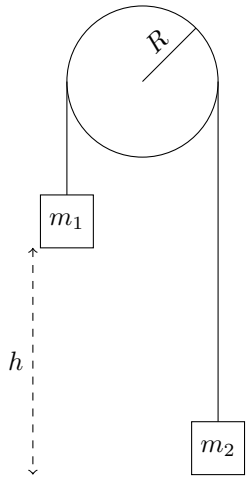
12) If an individual force applies a constant $\tau = +320$ Nm of torque to the object in the previous problem, how much work is done on the object by this force between $t = -2.0$ s and $t = 1.0$ s?

A) 11520 J
B) 960 J
C) 5760 J
D) 14050 J
E) 3340 J
F) 740 J

Answer LOs
A) 8, 14, 56
B) 56
C) 56
D)
E)
F)

13) The system below is called Atwood's Machine. Assume that $m_1 > m_2$, the pulley is in the shape of a disc with mass M and radius R and the system is released from rest. What is the sign of the total work done by tensions on the pulley during the time the boxes move through a displacement h? (Assume the rope goes over the pulley without slipping).

A) $W > 0$
B) $W = 0$
C) $W < 0$



Answer LOs
A) 32, 54, 56
B)
C)

14) A solid, uniform disk with a radius of 15.0 cm and a mass of 225 g is spinning at a constant rate of 12.0 rad/s. A second solid, uniform disk is dropped from a small height at rest so that it lands on the first disk. This disk has a radius of 10.0 cm and a mass of 100 g. After a short time, both disks are rotating about their centers as one. What is the work done by friction *on the larger disk* from the time the two make contact to the time they are moving as one?

A) -0.0301 J
B) -0.0757 J
C) -0.0552 J
D) -0.0904 J
E) -55.2 J
F) -30.1 J
G) -75.7 J
H) -90.4 J

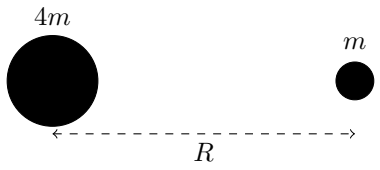
Answer LOs
A) 10, 35, 50, 57, 58, 59
B)
C) 10, 35, 50, 56, 57, 58, 59
D)
E) 35, 50, 56, 57, 58, 59
F) 35, 50, 57, 58, 59
G)
H)

15) At $t = 0$ a box that has a momentum of $\vec{p} = -3.45\,\hat{\imath}$ kg m/s begins to be acted on by a force $\vec{F}(t) = (0.286\,t)\,\hat{\imath}$ N. What is the impulse the force imparted on the object between $t = 1.0$ s and $t = 4.0$ s?

A) $+3.921\,\hat{\imath}$ kg m/s
B) $+2.288\,\hat{\imath}$ kg m/s
C) $+2.145\,\hat{\imath}$ kg m/s
D) $+0.771\,\hat{\imath}$ kg m/s
E) $-1.162\,\hat{\imath}$ kg m/s
F) $-1.305\,\hat{\imath}$ kg m/s
G) $-2.536\,\hat{\imath}$ kg m/s
H) $-3.546\,\hat{\imath}$ kg m/s
Answer LOs
A)
B) 47, 49
C) 8, 47, 49
D)
E) 47
F) 8, 47,
G)
H)

16) Assume that two objects in deep space are *at rest* relative to each other and separated by a distance R as shown in the figure below. Due to gravitational attraction, the two objects will eventually collide. If the left object has a mass $4m$ and the right object has a mass m, how far from the initial position of the left mass will they collide? Note that the figure is not to scale, treat R as much bigger than the radius of either object (Hint: Here, the gravitational force acts as an *internal force* and one does not need to know it's explicit form).

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



Answer LOs
A) 3, 45, 47, 48
B)
C)
D)
E)
F)
G) 45, 47, 48

17) Imagine a system where there is a small steel ball and a large steel cylinder. The steel ball is going to collide with the cylinder which is at rest. If the collision happens away from the center of mass of the cylinder which of the following quantities MUST be conserved during the collision? Assume there are no external forces acting on the system.

A) Linear momentum
B) Angular momentum
C) Kinetic energy
D) Linear momentum and angular momentum
E) Linear momentum and kinetic energy
F) Angular momentum and kinetic energy
G) All three
H) None of the three

Answer LOs
A) 46, 47, 48, 50
B) 50, 57, 58, 59
C)
D) 46, 47, 48, 50, 57, 58, 59
E) 46, 47, 48
F) 57, 58, 59
G) 46, 47, 48, 57, 58, 59
H)