Physics 211 Final Exam

This exam has twenty-seven multiple choice questions.

The exam period begins at 8 AM on May 19 and ends at 10 AM on May 19.

Exception: Students who receive an extra-time accommodation through the Center for Disability Resources may take that extra time. If you receive 1.5x time for the exam, you should complete your work by 11 AM; if you receive double time, you should complete it by noon. If this timetable does not work for you or you require additional accommodations, please contact Walter or Mario immediately.

Questions during the exam: You may reach teaching staff to ask questions during the exam by:

- Joining the course Zoom and asking by chat or voice
- Asking a question in `#quiz-questions` on Discord
- (Only if both of these methods are not available to you) Email to `wafreema@syr.edu`

You may:

- Consult any materials on the course website, video library, any of your notes, notes prepared in collaboration with your classmates, your previous homework, recitation work, quizzes, or the OpenStax textbook for reference
- Contact teaching staff over Zoom, Discord, or email to ask for clarification on any portion of the exam.
- Use a graphing calculator to do arithmetic or graph functions
- Make use of Google Calculator, Desmos, or similar tools to do arithmetic or graph functions
- Use a translation tool or dictionary to translate anything to your native language

You may not:

- Provide assistance to anyone else in our class on this exam while they are taking it
- Seek assistance from anyone other than teaching staff on this exam while you are taking it
- Use a computer program or calculator to do algebra for you
- Consult online references outside the class other than the OpenStax textbook (for example, Chegg and Bartleby) regarding the material on the exam after the exam period begins
- Discuss the contents of this exam with anyone who has yet to complete it

To submit your answers, simply type them into the text box on Blackboard as numbers followed by letters with spaces between them. An example might be `1 A 2 B 3 D 4 F 5 C`. You may also put them on different lines, e.g.

```
1 A
2 B
3 C
4 D
5 E
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Note: You should use $g = 10\,\mathrm{m/s^2}$ throughout this exam. The answers are calculated with this value.

1. In this question and the following two questions, I will give you several equations that *might* be part of a calculation in physics. However, only one of them could be; in the others, the units in different terms of the equation do not match – for instance, by adding a velocity to an acceleration or by setting a force equal to an energy.

   All symbols have their conventional meanings, *e.g.* v is a velocity, h is a height, etc. When L appears, it is a length, not an angular momentum.

   Which of the following equations could be plausibly part of a calculation since the dimensions in different terms match?

   (A) $\frac{2}{5}mR^2\frac{v^2}{r^2} - mgh = \frac{1}{2}kx^2 + \frac{1}{2}mv^2$
   (B) $x = \frac{1}{2}at^2 - v_0 \sin\theta - x_0$
   (C) $a = \frac{Mg - \mu mgL}{m+M}$
   (D) $\frac{1}{2}kL^2 + mgh - \mu mgL = \frac{1}{2}mv^2 + F_T v \cos\theta$
   (E) More than one of the above are dimensionally correct, or none of them are

2. Which of the following equations could be plausibly part of a calculation since the dimensions in different terms match?

   (A) $\frac{2}{5}mR^2\omega^2 + \frac{1}{2}mv^2 = \mu mg$
   (B) $L = \frac{\frac{1}{2}mv^2}{gt}$
   (C) $\sqrt{\frac{k}{m}} = 1/t$
   (D) $\frac{1}{2}mR^2\omega^2 = Mv - gt$
   (E) More than one of the above are dimensionally correct, or none of them are

3. Which of the following equations could be plausibly part of a calculation since the dimensions in different terms match?

   (A) $v = \sqrt{2gh} + \frac{kx}{m}$
   (B) $F_N = \frac{mg}{\mu} + \omega^2 r \cos\theta$
   (C) $MvR + \frac{1}{2}mr^2\omega = 0$
   (D) $x_1 = x_0 + \frac{1}{2}\frac{-k(L-L_0)}{m}t^2$
   (E) More than one of the above are dimensionally correct, or none of them are

4. One way for people to make a rapid, controlled descent is to grasp a pole and slide down it. They press against the pole using their arms or legs, using friction to slow their fall. This approach has historically been used by firefighters to quickly descend from their living quarters to a fire engine when called to a fire; more recently it is more commonly used by performers and acrobats.

   Suppose first that a person of mass m descends a pole of length L (imagine that this is around ten meters, as in a firehouse) of height h; they grip the pole with both hands and press in opposite directions, with each hand applying a force F_h. The coefficient of kinetic friction between their hands and the pole is μ_k.

   What is the work done by friction as they descend?

   (A) $W = 2\mu_k F_h L$
   (B) $W = -\mu_k mgL$
   (C) $W = -2\mu_k F_h L$
   (D) $W = \mu_k mgL$
   (E) $W = mgL$
   (F) $W = -\mu_k F_h$
   (G) $W = \mu_k F_h$

5. How fast will they be traveling after they descend the pole and reach the ground?

   (A) $v_f = \sqrt{2gL}$
   (B) $v_f = \sqrt{2gL + 4\frac{\mu_k F_h L}{m}}$
   (C) $v_f = \sqrt{2gL - 4\frac{\mu_k F_h L}{m}}$
   (D) $v_f = \sqrt{2gL + 2\frac{\mu_k F_h}{m}}$
   (E) $v_f = v_i - gt$
   (F) $v_f = \sqrt{2gL - 2\frac{\mu_k F_h}{m}}$
   (G) None of the above

6. Suppose now that a person of mass 75 kg wants to slide down a very long pole (several kilometers long, perhaps) at a constant rate. They adjust their grip on the pole to maintain their speed at the maximum safe rate possible.

   The energy lost to kinetic friction is converted into heat. Suppose that half of this heat goes into the pole (which we don't care about) and half of it goes into their hands. Suppose that their hands can absorb heat at a power of 300 W safely[a]. What is the fastest that they can slide down the pole without overheating their hands?

   (A) $v_{\text{max}} = 4$ m/s

   (B) $v_{\text{max}} = 1.6$ m/s

   (C) $v_{\text{max}} = 0.4$ m/s

   (D) $v_{\text{max}} = 0.2$ m/s

   (E) $v_{\text{max}} = 0.8$ m/s

   (F) $v_{\text{max}} = 4$ m/s

   (G) None of the above

   [a]Our protagonist has a supernatural tolerance to heat.

7. A person slides an object up a ramp inclined at an angle θ above the horizontal. The coefficient of kinetic friction between the object and the ramp is μ_k.

   What is the magnitude of the object's acceleration on its way up?

   (A) $g \sin\theta + \mu_k g \cos\theta$

   (B) g

   (C) $g \cos\theta - \mu_k g \sin\theta$

   (D) $g \cos\theta + \mu_k g \sin\theta$

   (E) $g \sin\theta + \mu_k g$

   (F) $g \sin\theta - \mu_k g \cos\theta$

   (G) $g \sin\theta - \mu_k g$

8. What is the magnitude of the object's acceleration on its way *back down*?

   (A) g

   (B) $g \sin\theta + \mu_k g$

   (C) $g \cos\theta + \mu_k g \sin\theta$

   (D) $g \sin\theta + \mu_k g \cos\theta$

   (E) $g \sin\theta - \mu_k g \cos\theta$

   (F) $g \cos\theta - \mu_k g \sin\theta$

   (G) $g \sin\theta - \mu_k g$

9. A slingshot is a device that uses an elastic band to propel a rock forward. The user places the rock into the slingshot and draws it back, then releases it. While it is not a spring, you can model the force that it applies to a rock as $F_e = k\Delta x$ in the same way.

   Suppose that a slingshot has spring constant k, and a user draws it back to a distance d and loads it with a stone of mass m.

   They then point it at a $45°$ angle above the horizontal and release it.

   How fast will the stone be traveling at the *highest point* of its flight?

   (A) $v_{\text{top}} = \sqrt{\frac{1}{2}\frac{k}{m}d^2}$

   (B) $v_{\text{top}} = \sqrt{\frac{k}{m}d^2}$

   (C) $v_{\text{top}} = \sqrt{2\frac{k}{m}d^2}$

   (D) $v_{\text{top}} = 2\sqrt{\frac{k}{m}d^2}$

   (E) $v_{\text{top}} = 0$

   (F) You can't figure this out unless you know the height above ground it was launched at.

10. A carnival ride consists of a large circular room with a radius R; people stand against the walls. This room is made to spin at an angular velocity ω. Then, the floor falls out beneath the people. Even though there is nothing underneath them, the people do not fall.

Draw a force diagram for a person against the wall (who is not falling). Suppose the person is facing to the left, with the wall behind them to their right (so left is inward, and right is outward). Which of the following describes the forces you have drawn on your diagram?

(A) The centripetal force pointing inward, the normal force pointing upward, friction pointing to the right, and gravity pointing downward

(B) Friction pointing left, gravity pointing downward, and a normal force pointing upward

(C) Friction pointing upward, gravity pointing downward, and a normal force pointing left

(D) Friction pointing to the right, the centripetal force pointing to the left, gravity pointing downward, and the normal force pointing upward

(E) A normal force pointing to the left and acceleration pointing to the right

(F) None of the above are correct.

11. If the coefficient of friction between the person's clothing and the wall is μ, their mass is m, and the radius of the room is r, calculate the minimum angular velocity ω that the room must rotate at such that the people do not fall.

(A) $\omega_{\text{min}} = \sqrt{\frac{mg}{r}}$

(B) $\omega_{\text{min}} = \sqrt{\frac{F_N}{r}}$

(C) $\omega_{\text{min}} = \sqrt{\frac{\mu g}{r}}$

(D) $\omega_{\text{min}} = \sqrt{\frac{\mu mg - F_c}{r}}$

(E) $\omega_{\text{min}} = \sqrt{\frac{g}{\mu r}}$

(F) None of the above

12. People riding this carnival ride feel their bodies pressed into the wall behind them.

After riding this carnival ride for a while, a person with sensitive skin complains that they have gotten a bruise on the back of their head because they felt something pushing their head from behind.

What force pressed on the person's head in order to create this bruise?

(A) The normal force from the wall pressed against their head.
(B) The angular velocity pressed against their head.
(C) There was no force pressing on their head; this is an illusion.
(D) The centrifugal force from the angular velocity pressed against their head.
(E) None of the above explanations is correct.

13. A car of mass 1000 kg is driving down an incline that is sloped at an angle 10° below the horizontal.

The driver wishes to decelerate from a speed of 10 m/s to a stop over a distance of 25 meters. They do this by applying a constant force from their brakes.

In the next three problems, you will determine various things about this process.

What is the magnitude of the acceleration of the car during this process?

(A) 0.347 $\mathrm{m/s^2}$
(B) 2 $\mathrm{m/s^2}$
(C) 4 $\mathrm{m/s^2}$
(D) 0.694 $\mathrm{m/s^2}$
(E) 0.173 $\mathrm{m/s^2}$
(F) None of the above is correct.

14. What traction force must the ground apply to the car to make it decelerate in this manner?

(A) 3763 N
(B) 264 N
(C) 3736 N
(D) 237 N
(E) 2000 N
(F) None of the above is correct.

15. What coefficient of friction between the car's wheels and the ground is required for the car to be able to decelerate in this manner?

    (A) 0.203
    (B) 0.379
    (C) 0.374
    (D) 1.015
    (E) 0.176

16. The speed of sound in air is around 340 m/s.
    Suppose that someone sounds an organ pipe that is 3.4 meters long. Which of the following frequencies will be among those that are produced?

    (A) 100 Hz
    (B) 200 Hz
    (C) 300 Hz
    (D) 50 Hz
    (E) All of the above

17. Someone has left a pile of French fries sitting on a piece of wood resting on the ice. The coefficient of friction between the wood and the ice is 0.2. The piece of wood and fries have a mass of 1 kg.

    An enterprising crow flies and lands on the wood to eat the fries; the crow has a mass of 500 g. Right before it grabs onto the wood, it is flying at 3 m/s horizontally.

    How far will the wood slide before coming to rest after the crow lands on it?

    (A) 0.25 m
    (B) 1 m
    (C) 0.5 m
    (D) 1.75 m
    (E) None of the above

18. A rugby player of mass $m_1 = 60$ kg is running straight north at 4 m/s when another rugby player runs and tackles him. This second player has a mass $m_2 = 90$ kg and is running east at 2 m/s.

After the tackle, how fast are they traveling?

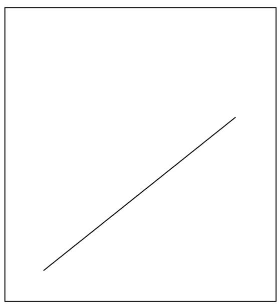
(A) 2.8 m/s
(B) 0.2 m/s
(C) 2 m/s
(D) 3 m/s
(E) 1 m/s
(F) None of the above are correct.

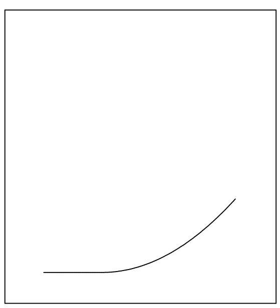
19. Two tall, vertical buildings are separated by a distance of 10 meters. A person drops a small rocket with a mass of $m = 1$ kg out of a window of one building.

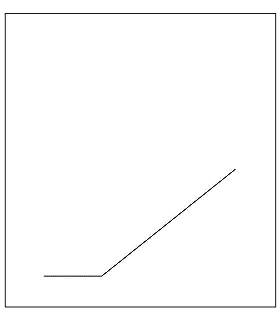
The rocket falls freely for one second, and then the rocket fires, applying a horizontal force $F = 5$ N to the rocket until it crosses the gap between the buildings and strikes the side of the other building.

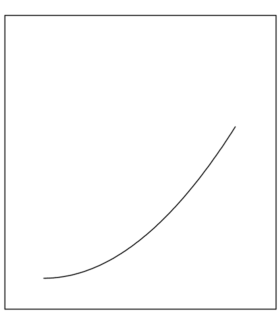
The next three questions concern this scenario.

Which of the following gives the general shape of the *horizontal component of the rocket's velocity as a function of time*, starting at the moment the rocket is dropped?

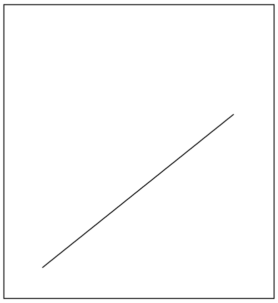
(A) 

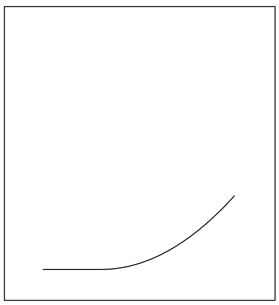
(B) 

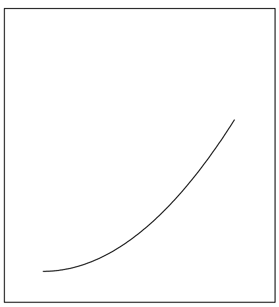
(C) 

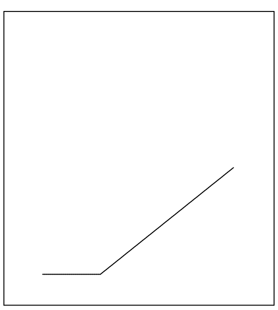
(D) 

20. Which of the following gives the general shape of the *vertical component of the rocket's position as a function of time*, starting at the moment the rocket is dropped? (These graphs are drawn such that the positive $y-$axis is downward.)

(A) 

(B) 

(C) 

(D) 

21. How far below the level of the window does the rocket strike the other building?

(A) 45 meters
(B) 5 meters
(C) 60 meters
(D) 40 meters
(E) Another value not listed here

22. In the next two problems, tell whether the quantity described must be positive, must be negative, must be zero, or could be some combination of them.

    The work done by the tension force acting on a pendulum as it swings back and forth...

    (A) ... must be zero
    (B) ... must be positive
    (C) ... must be negative
    (D) ... may be positive or zero
    (E) ... may be negative or zero
    (F) ... may be positive, negative, or zero

23. The work done by the force of static friction on an automobile driving at a constant speed of 100 km/hr on flat ground. *Do not neglect air resistance here.*

    (A) ... must be zero
    (B) ... must be positive
    (C) ... must be negative
    (D) ... may be positive or zero
    (E) ... may be negative or zero
    (F) ... may be positive, negative, or zero

24. The work done by the tension force acting on the bob of a pendulum as it swings back and forth...

    (A) ... must be zero
    (B) ... must be positive
    (C) ... must be negative
    (D) ... may be positive or zero
    (E) ... may be negative or zero
    (F) ... may be positive, negative, or zero

25. Two organ pipes have lengths of 12 feet and 16 feet.
Which of the following is true?

(A) The speed of the waves in the twelve-foot pipe is slower than the speed of the waves in the sixteen-foot pipe.

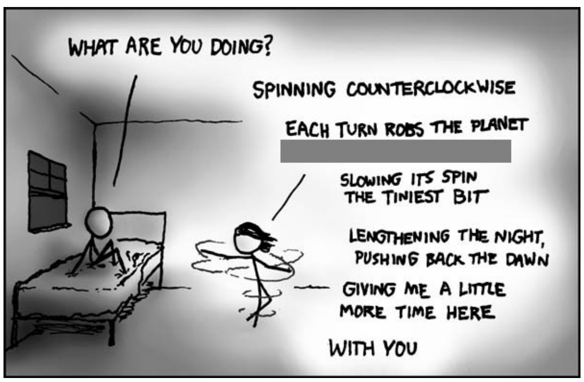
(B) The speed of the waves in the twelve-foot pipe is faster than the speed of the waves in the sixteen-foot pipe.

(C) The fundamental frequency of the twelve-foot pipe is 3/4 of the fundamental frequency of the sixteen-foot pipe.

(D) The fundamental frequency of the twelve-foot pipe is 4/3 of the fundamental frequency of the sixteen-foot pipe.

(E) None of the above are true.

26. Consider the following cartoon, equally geeky and adorable:



What quantity is she robbing the Earth of by spinning?

(A) Velocity

(B) Energy

(C) Angular momentum

(D) Momentum

(E) Gravity

27. The Earth rotates counterclockwise when seen from above the North Pole.

If her goal is to make the Earth rotate more slowly, where must she be located for this to work (even the slightest bit)?

(A) Somewhere in the Northern Hemisphere

(B) Exactly on the Equator

(C) Somewhere in the Southern Hemisphere