Name and Alpha: ______________________________

Instructor and Section: ______________________________

USNA Physics Department

SP211 101 Practice Problems

Just the odd problems!

About the actual final exam:

- The TI36XPro is the only allowed calculator.
- You may use your TI36XPro, writing utensils, and supplied scratch paper.
- Pack away everything else including ***cellphones*** and ***smartwatches***.
- Place your bag at the front of the room.
- Throughout the exam, use $g = 9.8\,\mathrm{m/s^2}$. Most problems use 2 significant figures.
- There is no penalty for guessing.
- Your instructor cannot answer questions about the exam or aid in interpretation.
- Write directly in the exam booklet showing your work and clearly circling your answers.
- A SCANTRON form is to be filled out after you have completed the entire exam.

<u>THE ANSWERS TO THESE PROBLEMS APPEAR ON THE LAST PAGE.</u>

1. You go for a 10 km "walk + run". You walk the first 5 km at 6 km/hr and then you run the next 5 km at 12 km/hr. Your average speed over the 10 km was

A. 9 km/hr

B. 11 km/hr

C. 10 km/hr

D. 8 km/hr

E. 7 km/hr

3. A particle's position as a function of time is given by $x = 7.0te^{-t}$ where x is in meters and t is in seconds. The particle's speed at $t = 3\,\text{s}$ is

A. 0.35 m/s

B. 0.23 m/s

C. 0.81 m/s

D. 0.58 m/s

E. 0.70 m/s

5. At $t = 0$, a particle's velocity is $v_{0x} = -30\,\text{m/s}$. For the depicted time-dependent acceleration, what is the particle's velocity at $t = 4\,\text{s}$?

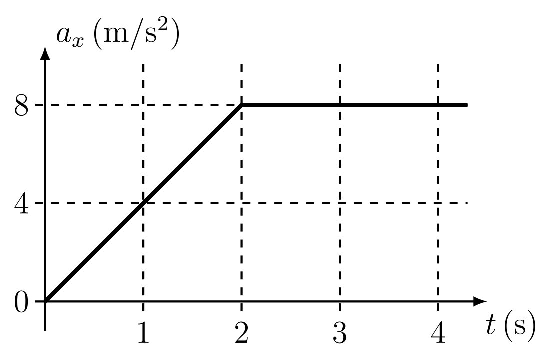
A. $v_x = +16\,\text{m/s}$

B. $v_x = +32\,\text{m/s}$

C. $v_x = +2.0\,\text{m/s}$

D. $v_x = -14\,\text{m/s}$

E. $v_x = -6.0\,\text{m/s}$



7. A Lockheed C-130 Hercules transport plane starting from rest achieves takeoff at a speed of $37\,\mathrm{m/s}$ after using up $640\,\mathrm{m}$ of runway. Assuming a constant accleration, what was the magnitude of the plane's acceleration down the runway?

A. $1.1\,\mathrm{m/s^2}$

B. $2.9\,\mathrm{m/s^2}$

C. $4.3\,\mathrm{m/s^2}$

D. $2.1\,\mathrm{m/s^2}$

E. $3.7\,\mathrm{m/s^2}$

9. Instantaneously, a particle's velocity $\vec{v}$ is to the left and its acceleration $\vec{a}$ is partly to the left and partly upwards. Qualitatively, at this instant, the particle is

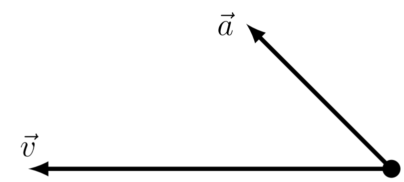
A. curving downwards and speeding up.

B. maintaining a constant speed.

C. curving upwards and speeding up.

D. curving downwards and slowing down.

E. curving upwards and slowing down.



11. The dashed line shows a car's path. At time t_1, the car's velocity is $\vec{v}_1$. At a later time t_2, its velocity is $\vec{v}_2$. The direction of the car's average acceleration from $t_1 \longrightarrow t_2$ is closest to

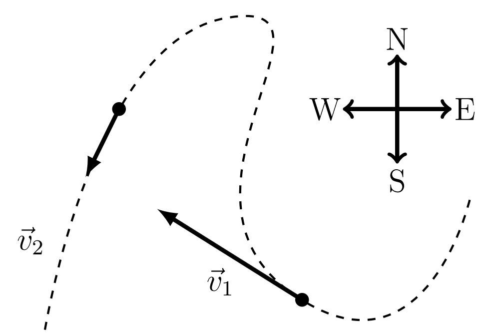
A. south

B. southeast

C. west

D. southwest

E. northwest



13. A projectile is released from a diving airplane. At release, this projectile shares the same velocity as the airplane itself. Neglecting air drag, where does the projectile land?

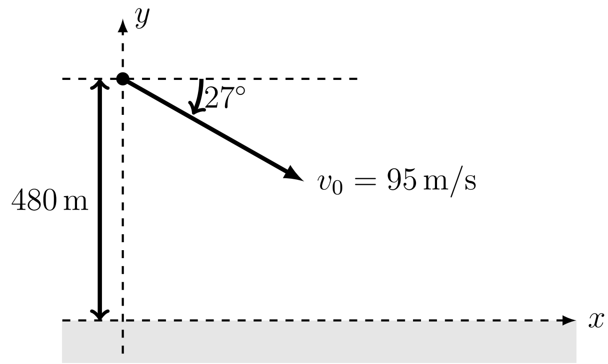
A. $x = 1300\,\mathrm{m}$

B. $x = 190\,\mathrm{m}$

C. $x = 400\,\mathrm{m}$

D. $x = 940\,\mathrm{m}$

E. $x = 540\,\mathrm{m}$



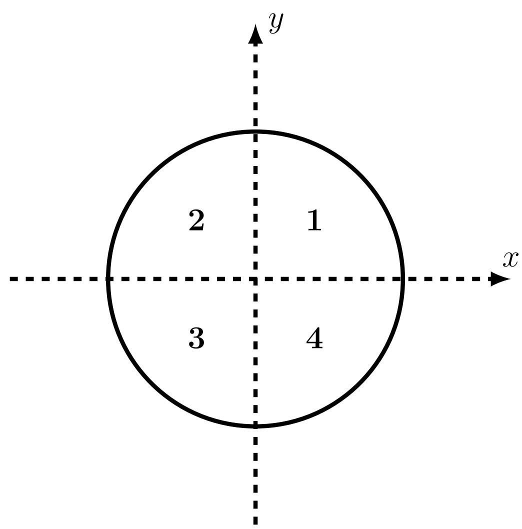
15. A particle is traveling counterclockwise in a circle in the xy plane around the origin. At some instant, its ***velocity*** is $\vec{v} = (1\,\mathrm{m/s})\hat{\imath} + (\text{-}3\,\mathrm{m/s})\hat{\jmath}$. At this instant, the particle's ***position*** is in which quadrant?

A. quadrant **1**

B. quadrant **2**

C. quadrant **3**

D. quadrant **4**



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17. The Electromagnetic Aircraft Launch System (EMALS) makes use of rotors to store and deliver energy. For a rotor of radius 0.90 m spinning at 6400 rpm (revolutions per minute), what is the centripetal acceleration of a point on the edge of the rotor?

A. $5.0 \times 10^5\,\mathrm{m/s^2}$

B. $3.0 \times 10^5\,\mathrm{m/s^2}$

C. $4.0 \times 10^5\,\mathrm{m/s^2}$

D. $2.0 \times 10^5\,\mathrm{m/s^2}$

E. $1.0 \times 10^5\,\mathrm{m/s^2}$

19. Relative to the ground, ship A travels ***east*** at 24 knots and ship B travels ***northwest*** at 13 knots. What is the speed of ship B relative to ship A?

A. 34 knots

B. 28 knots

C. 11 knots

D. 17 knots

E. 37 knots

21. A 0.70 kg puck moves in ***the horizontal*** xy ***plane.*** Shown is the complete free body diagram for the puck. The magnitude of the puck's acceleration is

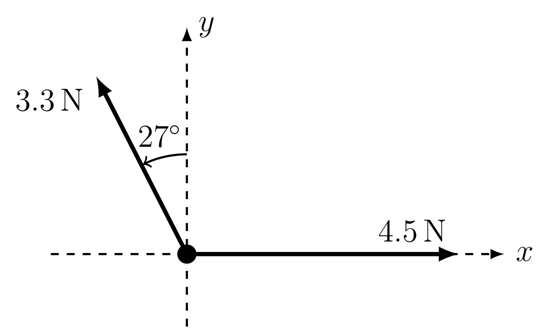
A. $1.7\,\mathrm{m/s^2}$

B. $6.0\,\mathrm{m/s^2}$

C. $8.0\,\mathrm{m/s^2}$

D. $3.1\,\mathrm{m/s^2}$

E. $9.5\,\mathrm{m/s^2}$



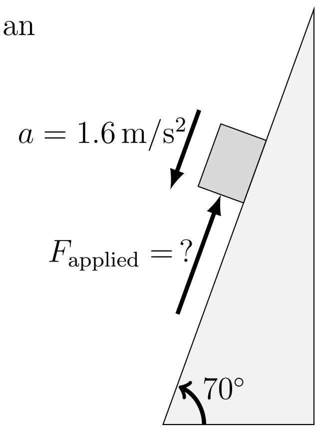
23. A person of mass m is standing in an elevator that is ***descending*** and ***slowing down***. How does the magnitude of the normal force exerted on the person by the elevator's floor compare to mg?

A. The magnitude of the normal force is smaller than mg.

B. The magnitude of the normal force is equal to mg.

C. The magnitude of the normal force is larger than mg.

25. This 3.0 kg block's speed increases as it descends this frictionless incline. Its acceleration is $1.6\,\mathrm{m/s^2}$ directed down the incline. This requires an applied force directed up the incline of magnitude



A. 34 N

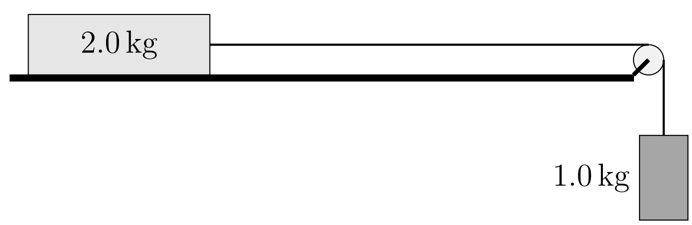
B. 29 N

C. 25 N

D. 23 N

E. 32 N

27. After being released, the 2.0 kg block ***accelerates to the right*** along the frictionless track as the 1.0 kg block ***accelerates downward.*** The pulley is massless and frictionless. What is the tension in the string?



A. 9.8 N

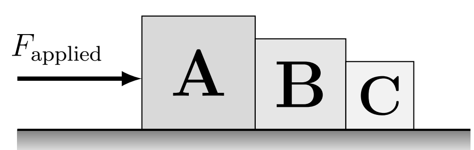
B. 6.5 N

C. 3.3 N

D. 4.9 N

E. 10 N

29. An applied force pushes these three boxes ($m_A > m_B > m_C$) along the frictionless floor. How does the magnitude of the force on A due to B, $|\vec{F}_{AB}|$, compare to that on B due to A, $|\vec{F}_{BA}|$?



A. $|\vec{F}_{AB}| = |\vec{F}_{BA}|$.

B. $|\vec{F}_{AB}| < |\vec{F}_{BA}|$.

C. $|\vec{F}_{AB}| > |\vec{F}_{BA}|$.

D. This depends on how $(m_B + m_C)$ compares to m_A.

31. A 120 kg linebacker tackles a 93 kg quarterback. How does the force the linebacker exerts on the quarterback compare to the force the quarterback exerts on the linebacker?

A. The force the quarterback exerts on the linebacker is always less in magnitude than the force the linebacker exerts on the quarterback.

B. When caught off guard, the force the quarterback exerts is often less in magnitude than the force the linebacker exerts.

C. With a proper stance, the force the quarterback exerts can match or even be greater in magnitude than the force the linebacker exerts.

D. The force the quarterback exerts on the linebacker is equal in magnitude to the force the linebacker exerts on the quarterback.

E. More than one of the above are possible.

33. A block rests on a level track. The coefficient of static friction between the block and the track is 0.62. Slowly raising one end of the track, at what angle (of the track above horizontal) will the block slip?

A. 58°

B. 38°

C. 45°

D. 32°

E. 52°

35. A 4.5 kg block is pulled along the floor by a 29 N tension force at 35° above horizontal. The coefficient of kinetic friction between the block and floor is 0.42. The magnitude of the block's acceleration is

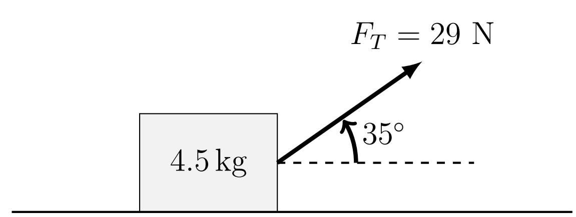
A. $1.2\,\mathrm{m/s^2}$

B. $2.3\,\mathrm{m/s^2}$

C. $1.9\,\mathrm{m/s^2}$

D. $3.4\,\mathrm{m/s^2}$

E. $2.7\,\mathrm{m/s^2}$



37. A 90 kg skydiver experiences a speed-dependent drag force $F_{\text{drag}} = 0.18\, v^2$ where F_{drag} is in newtons and v is in m/s. The skydiver eventually reaches a terminal speed of

A. 70 m/s

B. 60 m/s

C. 50 m/s

D. 80 m/s

E. 90 m/s

39. A projectile is launched at a shallow launch angle above horizontal. During the ***ascending*** part of the projectile's trajectory, ***the work done by gravity*** (on the block by Earth)

A. depends on one's choice of coordinate axes.

B. is ***positive*** and depends on the displacement along the vertical and the horizontal.

C. is ***negative*** and depends on the vertical and horitontal displacements.

D. is ***positive*** and depends only on the vertical displacement.

E. is ***negative*** and depends on the vertical and horizontal displacements.

41. A particle at rest at $x = 0$ experiences a net force that varies with position,

$$F_{\text{net}\,x} = 10\ e^{-x/2}.$$

where $F_{\text{net}\,x}$ is in Newtons and x is in meters. What is the particle's kinetic energy after it has traveled ***VERY far*** down the $+x$ axis?

A. 30 J

B. 10 J

C. 40 J

D. 50 J

E. 20 J

43. A 4600 kg elevator ***already in motion*** rises 30 m in 7.0 s at a constant speed by means of a cable attached to a motor. What is the motor's power while lifting the elevator at this constant speed?

A. 1.9×10^5 W

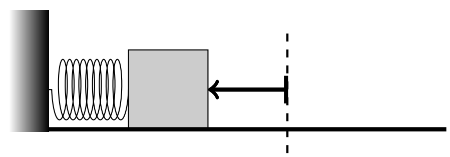
B. 2.1×10^6 W

C. 9.5×10^6 W

D. 3.2×10^6 W

E. 9.7×10^5 W

45. A spring compressed by 0.14 m and with a spring constant of 4200 N/m launches a 3.0 kg block down a frictionless hallway. What is speed of the block after launch?



A. 5.2 m/s

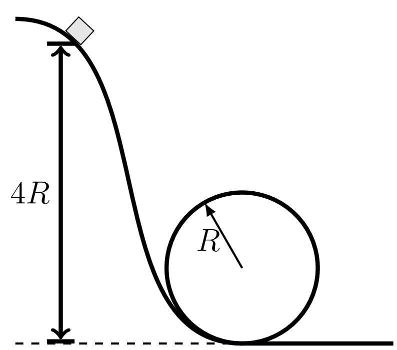
B. 1.8 m/s

C. 2.6 m/s

D. 3.7 m/s

E. 4.4 m/s

47. A block of mass m is released on this frictionless track from a height of $4R$. The ***normal force*** on the block as it passes upside-down through the ***TOP of the loop*** is



A. $2\,mg$

B. $3\,mg$

C. mg

D. $4\,mg$

E. 0

49. A particle moves along the x axis being acted upon by only a single force whose potential energy as a function of position x is shown and is described as

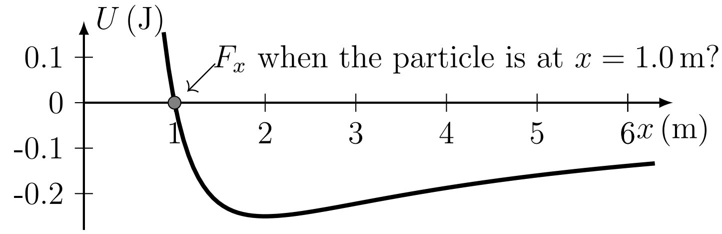
$$U(x) = \left(\frac{1}{x^2} - \frac{1}{x}\right)$$

where U is in joules and x is in meters. What is the force at $x = 1.0\,\text{m}$?

A. $F_{\text{net}\,x} = 0$

B. $F_{\text{net}\,x} = -1.0\,\text{N}$

C. $F_{\text{net}\,x} = +1.0\,\text{N}$



51. Dropping from rest from a helicopter, a 75 kg skydiver reaches a terminal speed of 54 m/s after descending 450 m. What is the thermal energy generated during this *"rest to terminal speed"* part of the dive?*

**HINT:* No need to treat drag force directly! General energy considerations are sufficient.

A. 4.4×10^5 J

B. 2.2×10^5 J

C. 5.5×10^5 J

D. 3.3×10^5 J

E. 1.1×10^5 J

53. Standing on a frictionless frozen pond, Emma and Zak hold opposite ends of a long massless pole of length L. Zak weighs twice as much as Emma. While Zak holds onto his end, Emma pulls herself along the pole until the two meet. During this process, approximately how far did Emma move?

A. $L/3$

B. $2L/3$

C. 0

D. $L/2$

E. L

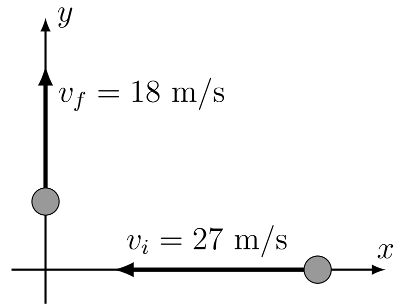
55. A projectile is launched at an angle above the horizontal. At some point during its parabolic trajectory, ***internal*** detonation explodes the projectile into multiple pieces. If we take air drag to be negligible, which of A and B is *TRUE*? **Choose C if both A and B are true.**

A. The explosion happens so quickly that to a good approximation momentum is conserved when we compare the projectile just before the explosion to the pieces just after the explosion.

B. Because the explosion is an internal process, the center of mass of this system continues to follow a parabolic trajectory until one of the pieces comes into contact with the ground.

C. **Both A and B are true.**

57. A bat strikes a ball. For these initial and final velocities, at what angle above the x axis is the average force exerted by the bat directed?



A. 90°

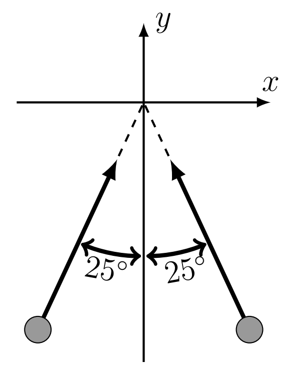
B. 56°

C. 0°

D. 45°

E. 34°

59. These equal mass pieces of clay each move with a speed of 10 m/s. They collide forming a single clay blob. The blob's speed is



A. 4.2 m/s

B. 10 m/s

C. 9.1 m/s

D. 7.1 m/s

E. 8.4 m/s

61. A wheel spins counterclockwise with an angular velocity of +120 rad/s. With a constant angular acceleration of $-16\,\mathrm{rad/s^2}$, how much time will it take to ***reverse*** the angular velocity to −120 rad/s?

A. 6 s

B. 7.5 s

C. 12 s

D. 10 s

E. 15 s

63. Identify which one of A → D is ***<u>FALSE</u>*** concerning rotational inertia. Choose E if A → D are all TRUE.

A. For rigid objects rotating around an axle, rotational inertia is affected by the object's rotational motion.

B. How rotational inertia appears in rotational contexts is analogous to how mass appears in linear contexts.

C. Rotational inertia addresses how the mass of an object is distributed around a rotation axis.

D. The units of rotational inertia are $\mathrm{kg \cdot m^2}$.

E. All of the above are TRUE.

65. A rectangular plate of width a and length b and mass M is mounted to an axle at one corner. The integral that calculates this plate's rotational inertia about this axle is

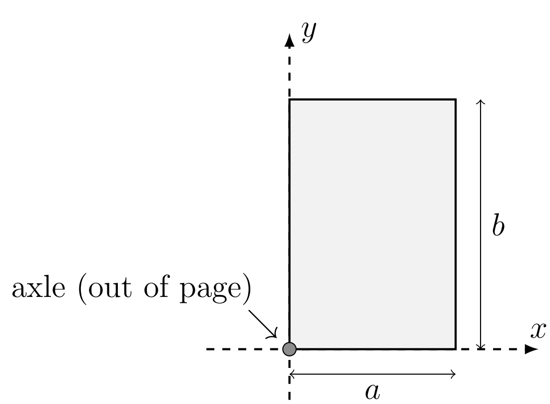
A. $\displaystyle\int_0^{\sqrt{a^2+b^2}} r^2 M dr$

B. $\displaystyle\int_0^a x^2 M dx + \int_0^b y^2 M dy$

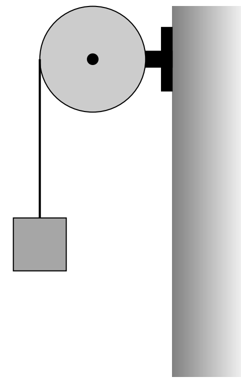
C. $\displaystyle\int_0^{\sqrt{a^2+b^2}} r^2 M \frac{dr}{\sqrt{a^2+b^2}}$

D. $\displaystyle\int_{y=0}^{y=b} \int_{x=0}^{x=a} (x^2+y^2) M \frac{dx\,dy}{ab}$

E. $\displaystyle\int_{y=0}^{y=b} \int_{x=0}^{x=a} (x^2+y^2) M\,dx\,dy$



67. The pulley has rotational inertia $I = 0.0030$ kg m^2 and radius $r = 0.050$ m. The 0.60 kg block descends as the cord unwinds without slipping. The magnitude of the block's acceleration is



A. 8.9 m/s^2

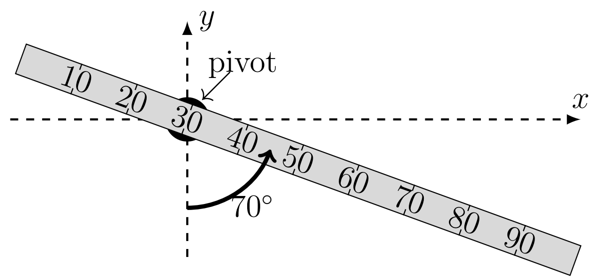
B. 3.3 m/s^2

C. 4.5 m/s^2

D. 9.8 m/s^2

E. 6.5 m/s^2

69. This 0.65 kg uniform aluminum meter stick is mounted to a pivot at the 30 cm mark. At 70° away from vertical, what is the torque exerted by gravity on this meter stick about the pivot?



A. 1.2 N·m

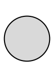
B. 4.5 N·m

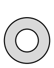
C. 3.7 N·m

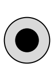
D. 3.5 N·m

E. 4.2 N·m

71. Four cylinders roll without slipping down a ramp starting from rest. Which cylinder completes the run down the ramp in the least time?

A.  A large solid cylinder of low density.

B.  Like cylinder A but with a hole drilled out.

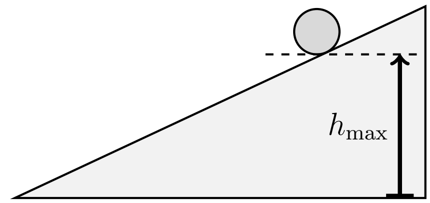
C.  Like cylinder B but with a high density core glued into the hole.

D.  Just the high density core on its own.

E. They all finish with the same time.

73. Two identical cylinders **A** and **B** roll without slipping along the horizontal at the same speed. **A** rolls onto an incline that has sufficient grip for **A** to keep rolling without slipping. **B** rolls onto a frictionless incline. The inclines have different slopes.

Which cylinder reaches the greatest height, h_{max}?



A. cylinder **A**

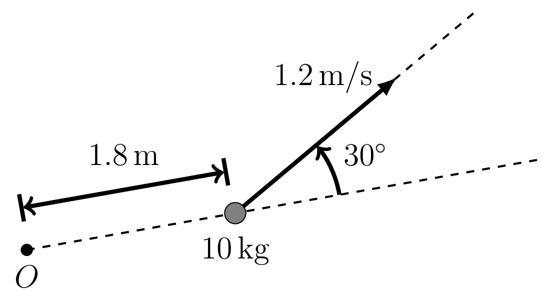
B. cylinder **B**

C. They reach the same maximum height.

D. The disk that rolls onto the incline of greater slope.

E. The disk that rolls onto the incline of lesser slope.

75. This 10 kg particle is 1.8 m from the origin O, moving at 1.2 m/s in the direction shown. Relative to O, the magnitude of the particle's angular momentum is



A. 11 kg·m^2/s

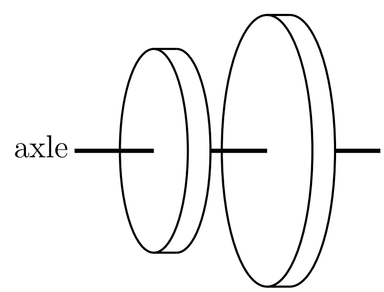
B. 41 kg·m^2/s

C. 24 kg·m^2/s

D. 22 kg·m^2/s

E. 32 kg·m^2/s

77. Two disks spin freely at different rates around a frictionless axle. With no external torque delivered, the disks are slid along the axle and brought into contact. After a short period of sliding against one another, the disks spin together as one. During this process, which of the following is/are conserved for this two-disk system?



A. **Kinetic Energy**

B. **Mechanical Energy**

C. **Angular Momentum**

D. *None of the above are conserved.*

E. *More than one of the above are conserved.*

79. An object weighs 100 N on Earth. This object on a planet that has twice the radius and twice the mass of Earth would weigh

A. 100 N

B. 50 N

C. 400 N

D. 200 N

E. 25 N

81. A space capsule is at rest at a distance of 3.0×10^7 m ***from Earth's center.*** If the capsule drifts from this position only from Earth's gravitational pull (no use of thrusters), what will be its speed when it reaches a distance of 2.0×10^7 m from Earth's center? Assume no thermal energy is generated.

A. 4500 m/s

B. 6300 m/s

C. 8900 m/s

D. 3600 m/s

E. 5200 m/s

83. Jupiter has an orbital radius around the Sun that is about 5 times larger than Earth's. What is the approximate orbital period of Jupiter in Earth years?

A. 5 Earth years.

B. 25 Earth years.

C. 15 Earth years.

D. 18 Earth years.

E. 11 Earth years.

85. An inground pool is filled to depth h_{max} with water of density ρ. Which integral gives the magnitude of the force exerted by the water on a sidewall of width w?

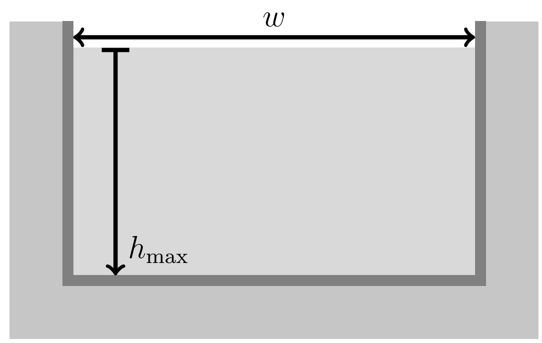
A. $\int_0^{h_{\text{max}}} (p_0 + \rho g h) h_{\text{max}}\, dh$

B. $\int_0^{h_{\text{max}}} (p_0 + \rho g h) \frac{w\, dh}{h_{\text{max}}}$

C. $\int_0^{h_{\text{max}}} (p_0 + \rho g h) \frac{h_{\text{max}}\, dh}{w}$

D. $\int_0^{h_{\text{max}}} (p_0 + \rho g h) dh$

E. $\int_0^{h_{\text{max}}} (p_0 + \rho g h) w\, dh$



87. A hollow sphere of outside radius 18 cm and inside radius 17 cm floats half submerged in fresh water. What is the density of the material used to make this hollow sphere?

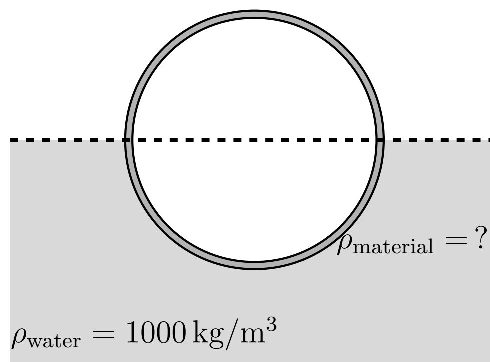
A. $2600\,\text{kg/m}^3$

B. $3200\,\text{kg/m}^3$

C. $5700\,\text{kg/m}^3$

D. $4000\,\text{kg/m}^3$

E. $4900\,\text{kg/m}^3$



89. A block oscillates up and down on the end of an ideal spring. Suppose we (1) catch the block at its lowest point, (2) pull it a bit further down, (3) then let go. Did our intervention change the period of oscillation ***and if so, how*** ?

A. Yes, the new period of oscillation is a bit shorter.

B. No, the period of oscillation is unchanged.

C. Yes, the new period of oscillation is a bit longer.

91. A small mass swings from the end of a string. Shown is the string's angle from vertical as a function of time. What is the string's length?

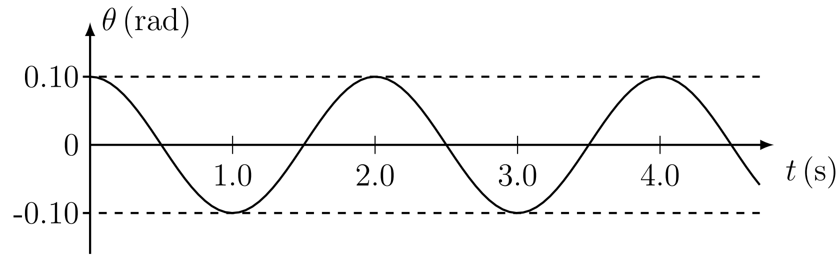
A. 1.6 m

B. 0.25 m

C. 2.2 m

D. 0.99 m

E. 0.35 m



93. A 0.70 kg block oscillates on the end of a spring. This system experiences damping with a damping constant $b = 0.15\,\text{kg/s}$. How long does it take for the amplitude of the block's oscillations to decay to half of its starting value?

A. 4.7 s

B. 6.5 s

C. 7.3 s

D. 8.4 s

E. 9.2 s

95. One example of an equation that describes a wave on a string is

$$y = (6.0\,\text{cm})\sin[(14\,\text{rad/m})\,x + (87\,\text{rad/s})\,t].$$

If the string's tension is 22 N, what is the string's linear mass density?

A. 0.81 kg/m

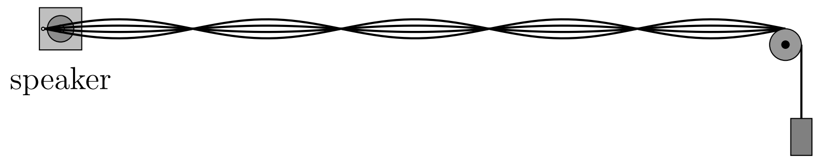
B. 0.57 kg/m

C. 0.25 kg/m

D. 0.64 kg/m

E. 0.45 kg/m

97. When this string under tension is driven at 240 Hz, you see the depicted standing wave. If you continuously ***decrease*** the driving frequency, the next frequency for which the string responds resonantly is



A. 192 Hz

B. 144 Hz

C. 171 Hz

D. 200 Hz

E. 160 Hz

99. For a given uniform medium (for instance: air at 0°C and 1 atm pressure), a sound wave's frequency is

A. proportional to its amplitude.

B. is independent of its wavelength and amplitude.

C. inversely proportional to its amplitude.

D. proportional to its wavelength.

E. inversely proportional to its wavelength.

101. An attack sub moves at a speed of 12.0 m/s through still water. As it approaches an underwater mountain it sends a 900 Hz sonar wave that travels through the water at 1482 m/s. The wave reflects off the mountain and the sub detects this reflected wave.

The sub detects a reflected frequency of

A. 893 Hz

B. 907 Hz

C. 886 Hz

D. 915 Hz

E. 900 Hz

SP211 101 Practice Problems
Just the odd problems!
Key

1 D	3 E	5 E
7 A	9 C	11 B
13 E	15 C	17 C
19 A	21 B	23 C
25 D	27 B	29 A
31 D	33 D	35 E
37 A	39 C	41 E
43 A	45 A	47 B
49 C	51 B	53 B
55 C	57 E	59 C
61 E	63 A	65 D
67 B	69 A	71 C
73 A	75 A	77 C
79 B	81 D	83 E
85 E	87 B	89 B
91 D	93 B	95 B
97 A	99 E	101 D