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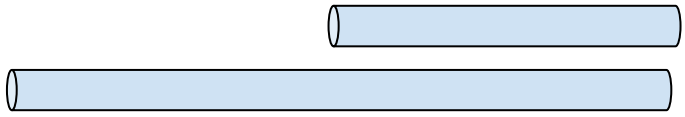
I. **Lecture Multiple Choice [60 pts]. Choose <u>only one</u> answer for each question and fill it out on your bubble sheet.**

30%

1. [5 pts] A long cylinder of radius 2.3 cm and length 5.4 m has its length doubled but its radius remains unchanged. By what factor does its surface area to volume ratio change? Hint: you can ignore the area of the end caps since they are so small compared to the length. RSA



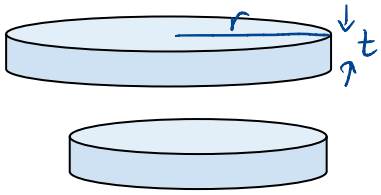
A. 1
B. 2
C. ½
D. 4
E. ¼

$R.SA = \frac{S}{V} = \frac{(2\pi r)\ell}{\pi r^2 \ell} = \frac{2}{r}$ ⇒ R.SA depends on r but not ℓ

⇒ R.S.A will not change when r is changed while ℓ kept const.

30%

2. [5 pts] Gold is about $85,000 per kg. To save money the queen decides to reduce the radius of each coin by 25% but doesn't change its thickness. By what percentage are the new coins cheaper to make, in terms of gold costs?



A. 25%
B. 44%
C. 56%
D. 75%
E. None of these

The amount of gold can be measured using volume

⇒ Price ∝ $V = \pi r^2 t$

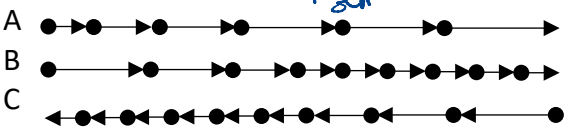
$\frac{\Delta Price}{Price_{old}} = \frac{V_{old} - V_{new}}{V_{old}} = \frac{\pi r_{old}^2 t - \pi r_{new}^2 t}{\pi r_{old}^2 t}$

$r_{new} = 0.75\, r_{old}$

$= \frac{r_{old}^2 - (0.75)^2 r_{old}^2}{r_{old}^2} = 1 - (0.75)^2 = 0.44$

38%

3. [5 pts] Which of the motion diagrams at right represent(s) an object first accelerating to the left then having zero acceleration?



A. A only.
B. B only.
C. C only.
D. A and B but not C.
E. B and C but not A.

In A: accel. to right then no accel ✗

In B: accel. to left then no accel ✓

In C: accel. to right then no accel ✗

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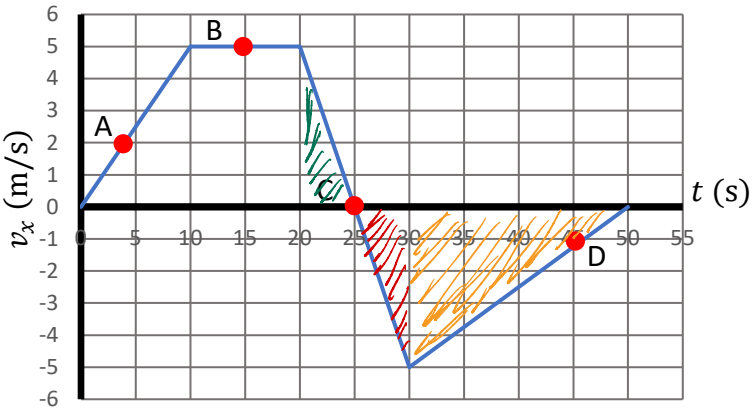
Use the following situation to answer the next three questions.

77%

The graph at right shows the velocity graph versus time for a car moving along the x-axis.



4. [5 pts] Rank the magnitudes (absolute values) of the car's acceleration at the designated points from highest to lowest.

   A. $a_C > a_A > a_D > a_B$
   B. $a_B > a_A > a_C > a_D$
   C. $a_A > a_D > a_B > a_C$
   D. $a_D > a_A > a_C > a_B$
   E. $a_C > a_D > a_A > a_B$

Accel. is slope: $a_x = \frac{\Delta v_x}{\Delta t}$

magnitude $\Rightarrow |a_x|$

5. [5 pts] The car is located at $x = 30$ m when $t = 20$ s. What is the car's position when $t = 50$ s?

   A. $x = -80$ m
   B. $x = -20$ m
   C. $x = 20$ m
   D. $x = 80$ m
   E. $x = 180$ m

59%

displacement = area under v vs. t curve

= green + red + orange area $= \frac{1}{2}(50s - 30s)(-5\frac{m}{s})$

$= -50\text{ m} = \Delta x = x_{50} - x_{20} = x_{50} - 30\text{m}$

$\Rightarrow x_{50} = -50\text{m} + 30\text{m} = \boxed{-20\text{m}}$

6. [5 pts] In which of the following intervals is the car moving in the $-x$ direction and speeding up?

   A. Between $t = 0$ s and $t = 10$ s
   B. Between $t = 10$ s and $t = 20$ s
   C. Between $t = 20$ s and $t = 25$ s
   D. Between $t = 25$ s and $t = 30$ s
   E. Between $t = 30$ s and $t = 50$ s

61%

To move in the $-x$ direction v_x must be negative: x: 25s → 50s

To speed up $|v_x|$ must get bigger:

x: 25s → 30s

44%

7. [5 pts] Pebble A is thrown up with an initial speed v and pebble B is thrown down with the same initial speed v. Which of the following statements is true about the motion of the two pebbles?

A moves more
Accel. is same
Wrong due to symmetry

   A. Both pebbles will hit the ground at the same time, since their initial speeds are identical.
   B. Pebble B will hit the ground first because it moves with a larger acceleration than Pebble A.
   C. Pebble A will have a smaller final speed than Pebble B when they hit the ground.
   D. Pebble A will have a larger final speed than Pebble B because it will drop from a greater height.
   E. Both pebbles will have the same final speed when they hit the ground.

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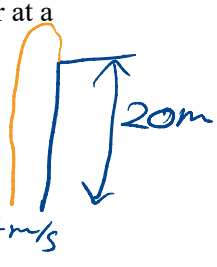
8. [5 pts] A stone is thrown straight up at the edge of a cliff 20 m above water. The stone hits the water at a speed of 17 m/s. At what speed was the stone thrown up?



A. 10 m/s
B. 26 m/s
C. 17 m/s
D. −30 m/s
E. −18 m/s

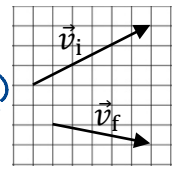
$(v_y)_f^2 = (v_y)_i^2 - 2g\Delta y$

$(17\frac{m}{s})^2 = (v_y)_i^2 - 2(9.8\frac{m}{s^2})(-20m)$

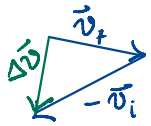
No answer possible !

Canceled
Full credit given to all

9. [5 pts] The two vectors shown represent the velocity vectors of an object at times t_i and t_f. Which one of the choices shown represents the direction of the object's average acceleration during that time interval, that is $\vec{a} = \Delta\vec{v}/\Delta t$?



$\Delta\vec{v} = \vec{v}_f - \vec{v}_i = \vec{v}_f + (-\vec{v}_i)$



A B C D E

39%

10. [5 pts] A researcher is tracking bears to study their feeding habits. One variable the researcher is studying is the distance between the bear's den and the position it finds it food. One bear in the study sets out looking for food by traveling 1.24 miles south of its den, then 0.720 miles west and finally 0.850 miles at an angle of 50.0° north of west. How far was the bear from its den when it found its food?

A. 2.81 miles
B. 1.87 miles
C. 1.40 miles
D. 1.79 miles
E. 1.31 miles

$\vec{d}_1 = (0, -1.24\text{mi})$ $\vec{d}_2 = (-0.720\text{mi}, 0)$

$\vec{d}_3 = (-0.850\cos 50.0°, 0.850\sin 50.0°)$

$\Rightarrow d = \sqrt{d_x^2 + d_y^2}$

$= \sqrt{(0 - 0.720 - 0.850\cos 50°)^2 + (-1.24 + 0 + 0.850\sin 50°)^2}$

53%

11. [5 pts] A ball is kicked with an initial speed of 15 m/s at some angle θ relative to the horizontal. During its flight, the minimum speed by the ball was 12 m/s. Calculate the launch angle θ.

A. 53°
B. 43°
C. 37°
D. 69°
E. The information provided is not enough to answer.

Min speed happens at max. height and is v_x

$\Rightarrow v_x = v_i\cos\theta \Rightarrow \cos\theta = \frac{v_x}{v_i} = \frac{12}{15} = 0.8$

$\Rightarrow \theta = \cos^{-1} 0.8 = 37°$

45%

12. [5 pts] An ice skater slides forward on frictionless ice without interacting with anything. How does the skater continue to move forward?

A. They cannot, their speed must increase or decrease. ✗ friction neglected
B. A force pushes them forward at a constant speed. ✗ no force is needed for const. $\vec{v}$
C. Their accelerations cancel each other out allowing them to move at a constant velocity.
D. Their inertia keeps them moving forward with constant velocity. ✓ 1st law
E. None of these apply

82%

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II. Free response questions 13-16 [20 pts]: Please show work or explain reasoning for full credit.

A humanitarian relief plane is carrying a crate filled with supplies and is flying level with the ground with a constant velocity of 65 m/s. Ignore air resistance for all problems.

1. [5 pts] What is the velocity (direction and magnitude) of the crate the instant after it is dropped from the airplane?

59%

v=65 m/s in +x direction. No other component yet.

2. [5 pts] If the plane is at a height of 500 m, how much time will it take for the crate to reach the ground?

70%

Now only need y-direction to find the time.

Use $y_f=y_o+v_{0y}\,t + \frac{1}{2}\,a_y\,t^2$, *solve for t:* $t = \sqrt{\frac{2\,y_o}{g}}$

$t = \sqrt{\frac{2 \times 500\text{m}}{9.8\ \text{m/s}^2}} = 10.1\ \text{s}$

$t =$ 10 s

3. [5 pts] If the target is 350 m in front of the airplane (along the ground in the +*x* direction) will the crate hit its target?

54%

Solve for x direction using previous time and velocity in the x-direction: $x_f=x_o+v_{ox}\,t + 0$ *as there is no acceleration in the x-direction.*

$x_f=0 + 65\ \text{m/s}\ 10\text{s} = 650\ \text{m}$

Answer: No, it will overshoot the target by quite a bit.

4. [5 pts] What is the velocity of the crate the instant before it hits the ground? Both magnitude and direction.

We need both the x and y components of the final velocity, and we already have the x component so we need only calculate the y-component.

35%

$v_{fy}^2=v_{0y}^2-2g(y_f-y_o)=0 - 2\ (9.8\ \text{m/s}^2)(0-500\text{m})=9800\ (\text{m/s})^2$

$v_{fy}=99\ \text{m/s}$

The magnitude is the sum of the squares, $v_f = \sqrt{v_x^2 + v_y^2}$ *=118.4 m/s*

The angle is from the +x axis given by $\tan(\theta) = \frac{v_y}{v_x}$, $\theta = \tan^{-1}\frac{99\ \text{m/s}}{65\ \text{m/s}}$ *=56.7°*

$v =$ 120 m/s Direction: 57° below x-axis (clockwise)

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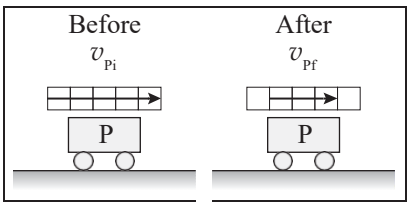
III. Tutorial Free Response [20 pts] Explain your answer where required.

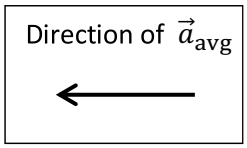
17. [5 pts] A worm absorbs oxygen at its skin at a rate of $0.22\ \mu\text{mol/cm}^2$ every hour and consumes oxygen at a rate of $0.95\ \mu\text{mole/g}$ every hour. If the surface area of the worm is $17\ \text{cm}^2$ and its mass is 3.8 g. Is the worm able to survive? Explain your answer briefly.
Solution:
59%
We first find the total amount of oxygen absorbed per hour: $(0.22\ \mu\text{mol/cm}^2) \times (17\ \text{cm}^2) = 3.7\ \mu\text{mol}$. Next, we find the total amount consumed per hour: $(0.95\ \mu\text{mol/cm}^2) \times (3.8\ \text{cm}^2) = 3.6\ \mu\text{mol}$. The worm would survive, because the amount of oxygen absorbed per hour is more than the mount consumed per hour.

Cart P moves along with an initial velocity on a level, frictionless track. It collides with cart Q (not shown). The initial and final velocities of cart P are shown at right.

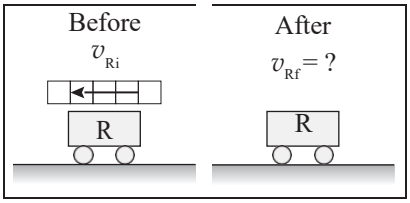


18. [5 pts] Draw a vector indicating the direction of the average acceleration of cart P during the collision.

83%

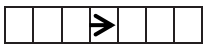


Cart R moves along the same track and collides with cart S (not shown). The initial velocity of cart R is shown at right. Both collisions (PQ and RS) occur over the same time interval Δt. The magnitude of the average acceleration of cart R is *twice* that of cart P, and in the *opposite* direction.



19. [5 pts] In the grid below, draw a vector indicating the final velocity of cart R. Draw the vector to scale. Explain.

47%



Solution:
The magnitude of the average acceleration of cart R is twice that of cart P, and in the opposite direction. Since the change in velocity of cart P is 2 units to the left, then in the same time interval, the change in velocity of cart R is 4 units to the right. Since $\vec{v}_{Ri} + \Delta\vec{v} = \vec{v}_{Rf}$, the final velocity of cart R is 1 unit to the right.

20. [5 pts] A cart is given an initial push on a flat horizontal frictionless track. It passes point *P* then *Q* and then *R*, after which the track is inclined at an angle. The cart keeps moving until it stops at point *S*. In the space provided, plot a graph of the cart's speed v versus time t and assume the time between each two consecutive locations is 0.5 s.

68%