$$\mathbf{F} = m\mathbf{a}$$

$$y = r\sin(\theta)$$

$$V_{sphere} = \frac{4}{3}\pi r^3$$

$$R = \frac{v^2\sin(2\theta)}{g}$$

$$r = \sqrt{x^2 + y^2}$$

$$a_c = \frac{v^2}{r}$$

$$v \equiv \frac{dx}{dt}$$

$$\tan(\theta) = \frac{y}{x}$$

$$F_f = \mu F_n$$

$$a \equiv \frac{dv}{dt} = \frac{d^2x}{dt^2}$$

$$A_{circle} = \pi r^2$$

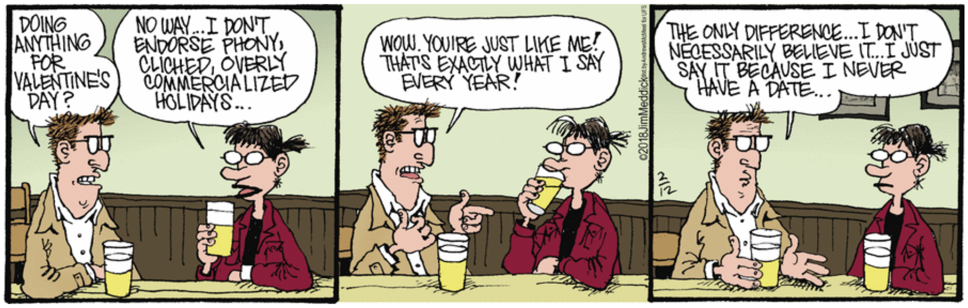
$$F_c = m\frac{v^2}{r}$$

$$x = r\cos(\theta)$$

$$A_{sphere} = 4\pi r^2$$

$$\rho = \frac{m}{V}$$

| Constant | Symbol | Approximate Value |
|---|---|---|
| Acceleration of Gravity (near Earth) | $g$ | 9.80 $m/s^2$ |
| Speed of light in vacuum | $c$ | $3.00 \times 10^8$ m/s |
| Atomic Mass Unit | $u$ | $1.67 \times 10^{-27}$ kg |
| Avogadro's Number | $N_A$ | $6.022 \times 10^{23}$ |


DOING ANYTHING FOR VALENTINE'S DAY?
NO WAY...I DON'T ENDORSE PHONY, CLICHED, OVERLY COMMERCIALIZED HOLIDAYS...
WOW. YOU'RE JUST LIKE ME! THAT'S EXACTLY WHAT I SAY EVERY YEAR!
THE ONLY DIFFERENCE...I DON'T NECESSARILY BELIEVE IT...I JUST SAY IT BECAUSE I NEVER HAVE A DATE...

Name:________________________________________ Score: ______/42

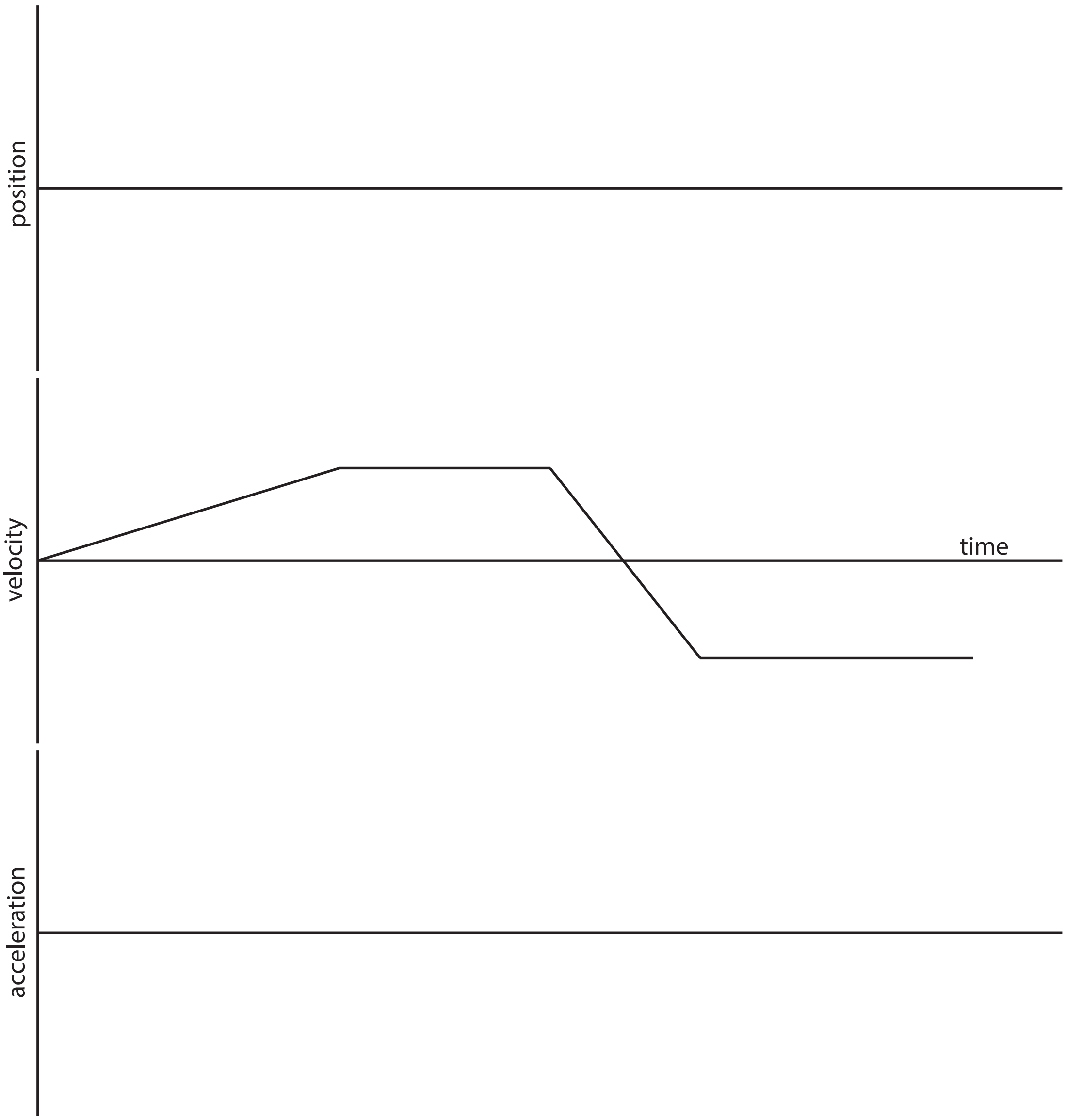
**Physics 204A** **Exam 1 — February 14, 2018**

Short-answer problems: Do any seven problems and clearly mark the one you wish to omit by drawing a diagonal line through the answer space. Show your work for complete credit. Six points each.

1. On his Olympic speed skating tryouts, Brendan was moving at 18 m/s when he fell and began sliding. After sliding for 13 m, he hit the edge of the rink at 8 m/s. What was his acceleration during the slide?

2. A cylinder has diameter 5.4 cm and height 75 mm. What is its volume in SI units?

3. Sketch graphs of position $x$ and acceleration $a$ corresponding to the velocity graph given below.




4. A particle's velocity is described by the equation $v_x = \left(t^2 - 7t + 10\right)$ m/s, where $t$ is in seconds. What is the acceleration of the particle at any turning-point times?

5. Nicholas begins riding his bike up a 200 m slope at a speed of 5 m/s, decelerating at 0.20 $m/s^2$ as he goes up. At the same instant, Isabelle starts down from the top at a speed of 2.0 m/s, accelerating at 0.40 $m/s^2$ as she goes down. How far does Nicholas go before they pass?

6. Meghan's velocity is $(2.0\hat{\imath} - 1.0\hat{\jmath})$ m/s. What is her direction and speed?

7. Mitchell is flying a rescue plane and needs to drop a self-inflating life raft to Julio, who is swimming in the ocean and fending off sharks with a rolled-up copy of a physics exam. Mitchell's plane is flying level at an altitude of 100 m with a speed of 45 m/s. He's flying directly towards Julio. If he drops the raft directly over Julio, how far will Julio have to swim to get to the raft?

8. Olivia is training at NASA for a Mars mission, and one of the standard training regimens for an astronaut is the centrifuge. The strap her into a chair at the end of a 12-m arm, then spin the arm in a circle around the other end so that Olivia experiences an acceleration of $9g$. (88 m/s$^2$.) At what speed is Olivia moving?

**Physics 204A** **Key** **Exam 1 — February 14, 2018**

Short-answer problems: Do any seven problems and clearly mark the one you wish to omit by drawing a diagonal line through the answer space. Show your work for complete credit. Six points each.

1. **Answer:** His average speed during the slide was 13 m/s, so it took him $\Delta t = 1$ s to change his velocity by -10 m/s. His acceleration was then $a = -10$ m/s$^2$.

2. **Answer:**

$$V = 1.72 \times 10^{-4} \text{ m}^3$$

3. **Answer:** Scale and absolute position will vary, but answers should look something like this:

4. **Answer:** Turning points are when $v = 0$, so

$$t = \frac{-7 \pm \sqrt{49-40}}{2} = \{-2, -5\} \text{ s}$$

The acceleration is the derivative of velocity, so

$$a = \frac{dv}{dt} = 2t + 7$$

Plug the above times into that:

$$a = \{3, -3\} \text{ m/s}^2$$

5. **Answer:** First, choose a coordinate system and *make sure you keep the directions straight!* I'll use the bottom of the hill as zero, with up being positive. Isabelle's initial velocity is then $v_{iI} = -2$ m/s, for example.
Nicholas's position is given by

$$x_N = x_{iN} + v_{iN}t + \frac{1}{2}a_N t^2$$

Isabelle's position is given by the same equation, with different values:

$$x_I = x_{iI} + v_{iI}t + \frac{1}{2}a_I t^2$$

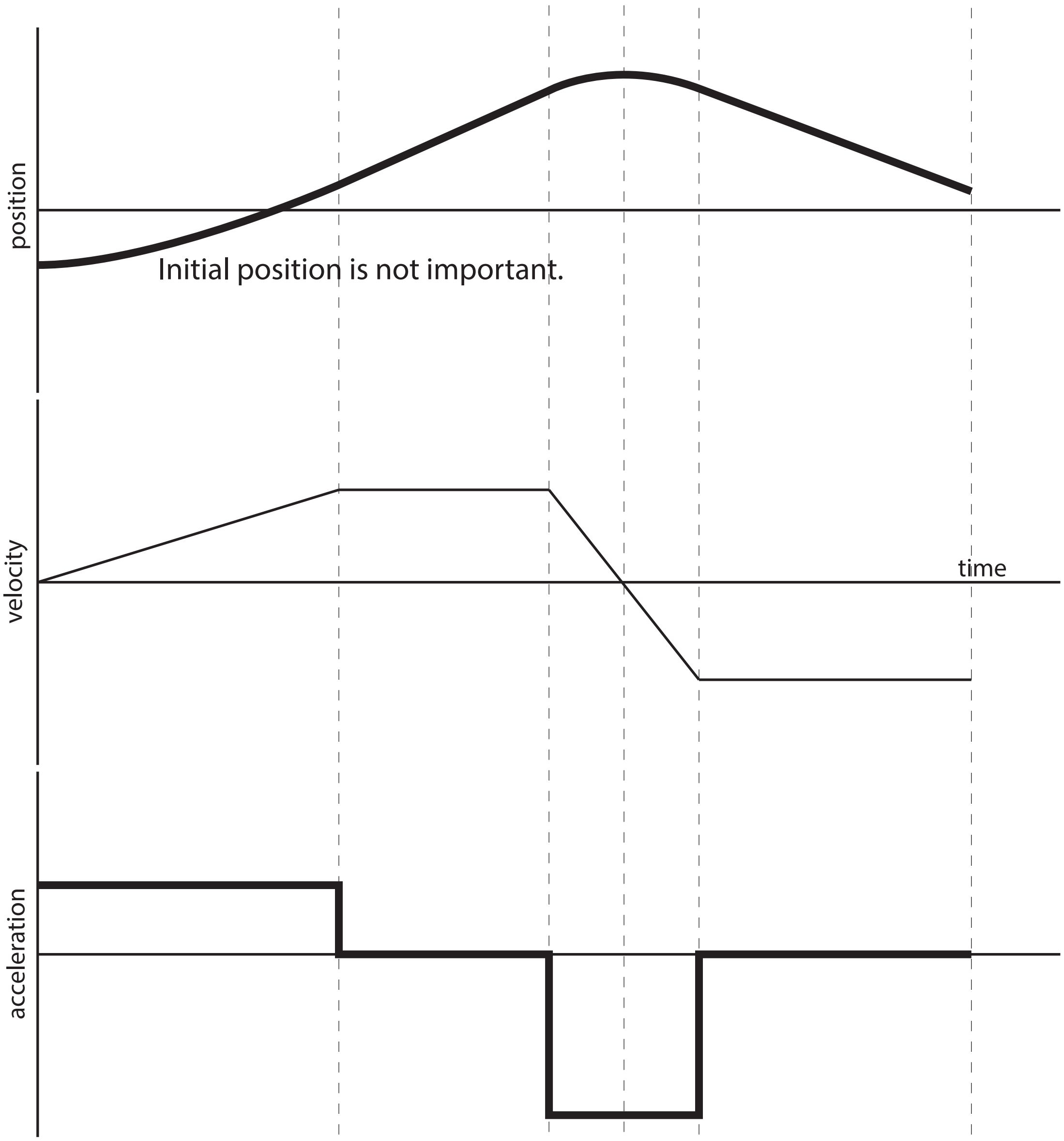
When they pass, they're at the same position so $x_N = x_I$.

$$v_{iN}t + \frac{1}{2}a_N t^2 = x_{iI} + v_{iI}t + \frac{1}{2}a_I t^2$$

$$0 = x_{iI} + (v_{iI} - v_{iN})t + \frac{1}{2}x_{iI}(a_I - a_N)$$

Use quadratic equation at this point: $t = 21.8$ s. Plug that time back into Nick's position equation:

$$x_N = 61.5 \text{ m}$$




6. **Answer:** Her speed is $v = \sqrt{5} = 2.24$ m/s. The direction $\theta$ is given by

$$\tan\theta = \frac{-1}{2} = -0.46 \text{ radians} = -27^\circ$$

7. **Answer:** Use the vertical position to determine the time it takes to reach sea level:

$$y = h + v_{iy}t + \frac{1}{2}a_y t^2$$

$$0 = h - \frac{1}{2}gt^2$$

$$t = \sqrt{\frac{2h}{g}}$$

Given that fall time, find the horizontal distance travelled by the raft:

$$x = v_{ix}t = 203 \text{ m}$$

8. **Answer:** Use centripetal acceleration:

$$a = \frac{v^2}{R}$$

$$v = \sqrt{aR} = 32.5 \text{ m/s}$$