Name:_____ Student number: _____

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Question #	Mark	Maximum Mark
Multiple Choice		20
11		10
12		10
13		10
14		10

Total = /60

Enter your answers to the multiple choice questions here by blackening in the circle corresponding to the best answer. There is only one correct answer per question.

1. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
2. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
3. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
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6. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
7. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
8. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
9. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
10. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

There are 10 multiple choice questions. Select the correct answer for each one and mark it on the bubble form on the cover sheet. Each question has only one correct answer. (2 marks each)

1. Which of the following set of numbers has the same standard deviation as {45, 47, 49, 51, 53}?

   (a) {44, 46, 48, 52, 54}

   (b) {45, 49, 53}

   (c) {2, 4, 6, 8, 10} Correct

   (d) {1, 2, 3, 4, 5}

   (e) none of the above

   The numbers in option (C) are all just 43 less than those in the question. So the means are different but the residuals are the same and thus the standard deviations are the same.

2. The following motion diagram represents acceleration of +5 m/s^2.

   What acceleration does the next diagram represent?

   (a) +5 m/s^2 Correct

   (b) +10 m/s^2

   (c) −5 m/s^2

   (d) −10 m/s^2

   (e) None of the above

   The direction of motion is changing sign, but also the motion goes from slowing to speeding, Both changes cause the sign to flip and hence the result is no change in sign. The corresponding step sizes in both cases are the same so the magnitude remains 5 m/s/s.

3. Felix the cat leaves his home and wanders 200 m up the street and then turns around and comes back −50 m. Felix's total displacement is

   (a) 200 m

   (b) −50 m

   (c) 250 m

   (d) 150 m Correct

   (e) none of the above

   I just used this question so I could put in the picture of Felix. The displacement is the NET change in position.

4. An object has velocities at two consecutive times as illustrated by the following arrows that show the magnitude and direction of the velocities at times t_1 and t_2 where t_1 is before t_2.

   v_1 $\longrightarrow$ v_2 $\longleftarrow$

   The acceleration of the object could be represented by

   (a) $\rightarrow$

   (b) $\leftarrow$ Correct

   (c) zero

   When something is moving and changing direction then the acceleration is in the direction of the final velocity.

5. The time-of-fall of a ball is measured 10 times. The average time is 1.542 seconds and the standard deviation of the 10 measurements is 0.036 seconds. Which of the following would be the best way of writing this result?

   (a) 1.54 ± 0.04 s

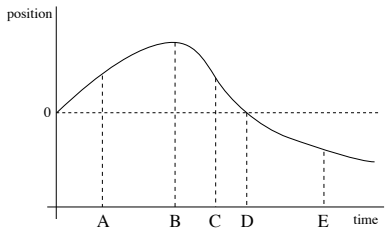
   (b) 1.542 ± 0.011 s Correct

   (c) 1.542 ± 0.004 s

   (d) 1.542 ± 0.036 s

   The standard deviation can be considered a measure of the uncertainty of a single measurement of a number of measurement. The standard deviation of the mean ($\sigma/\sqrt{N}$) i a measure of the uncertainty of the average of a number of values. In this case $\sigma = 0.036$ s so $\sigma/\sqrt{N} = 0.011$ s.

6. Here is a position-vs-time graph of a car moving along a straight stretch of road:

At which time of the times **A**,B,C,D or E does the car have the highest positive velocity?

The greatest slope occurs at (A).

7. Consider again the graph for the previous question. At which time (A,B,C,**D** or E) does the car have the highest positive acceleration?

   The curvature where the slope goes from negative to less negative represents positive acceleration. Position (D) has the most positive curvature .

8. The trajectory of a projectile with initial velocity in the horizontal direction can be expressed by the formula $y(x) = cx^2$ where c is a constant and x and y are in metres. What are the dimensions of c?
   (a) m^{-1} Correct
   (b) m^{-2}
   (c) m/s^2
   (d) m^2
   (e) none of the above

   The units of c must be such than when multiplied by m^2 one is left with dimensions of m.

9. In an Excel spreadsheet you wish cell D10 to contain a formula that calculates the average of cells D2 through D8. In D10 you would enter
   (a) average(D2,D8)=
   (b) =average(D2:D8) Correct
   (c) avg(D2,D8)=
   (d) =ave(D2..D8)
   (e) none of these

   That's the way it is.

10. A train ($v_0 = 0$ km/h) speeds up at a constant rate for 20 minutes, then travels at +80 km/h for 40 minutes and then slows down at a constant rate for the next 20 minutes until it is fully at rest again. What is its average velocity during those 80 minutes? (Hint: Draw a graph and figure it out.)
    (a) 0 km/h
    (b) 20 km/h
    (c) 40 km/h
    (d) 60 km/h Correct: D
    (e) 80 km/h

    During the first and last 20 minutes of acceleration the average speed is 40 km/h. The other 40 min travel is at 80 km/h so the average over the entire 80 min is60 km/h. Alternatively on could calculate the distance gone in the 3 segments as

$$v_{\text{avg}} = \frac{(20/60)\text{ h} \times 40\text{ km/h} + (40/60)\text{ h} \times 80\text{ km/h} + (20/60)\text{ h} \times 40\text{ km/h}]}{(80/60)\text{ h}}$$

.

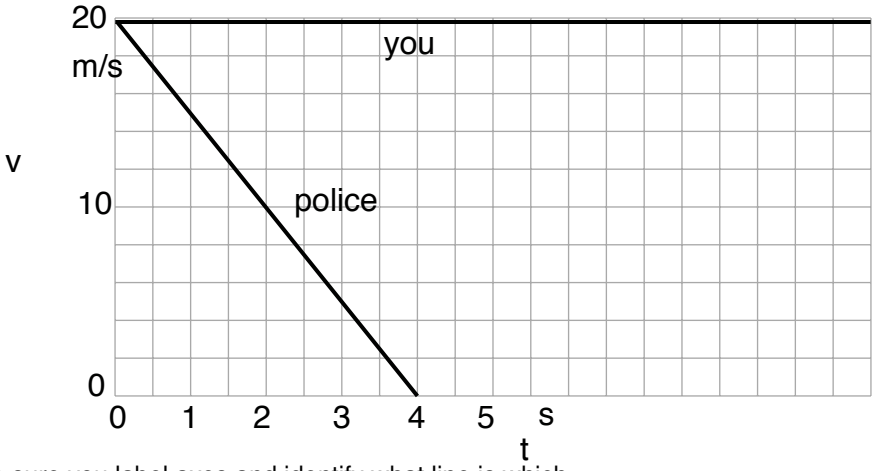
$$= 60\text{ km/h}$$

There are five written problems. Show all your work and explain your reasoning to get full credit.

11. You are arguing over a cell phone while trailing an unmarked police car by 25 m; both your car and the police car are travelling at 72 km/h. Your argument diverts your attention from the police car for 2.0 s (long enough for you to look at the phone and yell, "I won't do that!"). At the beginning of that 2.0 s, the police officer begins emergency braking at 5.0 m/s^2. You continue without braking until you hit the police car. [10 marks]

    (a) Draw the velocity-time graph for your car and the police car in the space below. Label the axes and include the units.

    First of all convert from 72 km/h to m/s, not necessary but recommeded:
    (72 km/h)(1000 m/km)(1 h/3600 s) = 20 m/s



    Make sure you label axes and identify what line is which.

    (b) How long does it take you to hit the police car after the police car starts braking?

    It's easier to do this by imagining you're in your reference frame, so that the police car is accelerating towards you at 5 m/s^2.

    The time needed to close the 25 m gap is give by solving:

$$\Delta x = \frac{1}{2}at^2$$

$$t = \sqrt{\frac{2\Delta x}{a}}$$

$$t = \sqrt{\frac{2 \times 25m}{5\ m/s^2}} = 3.16\ s$$

    (c) Assume that you start braking after your attention returns at 2 s, what minimum acceleration would you need to avoid hitting the police car? (Hint: work out the total distance that the police car travels.)

    It takes the police 40 m to stop, that's the area under the police car's velocity line: 40 m. The initial gap was 25 m so you have 65 m in which to stop.

    In the first 2 seconds you use up 40 m of that 65 m. So the time you need to stop in the remaining 25 m while slowing from 20 m/s to 0 is given by

$$\Delta v/2\Delta t_s = \Delta x_s$$

$$t_s = 2\Delta x_s/\Delta v$$

$$t_s = 2(25\ m)/(-20\ m/s) = 2.5\ s$$

$$a = \Delta v/t_2 = -20/2.5 = -8\ m/s^2$$

12. Bob wants to kick a soccer ball to his friend Chris standing on the other side of a river. He launches the ball at an angle of $\theta = 40°$ to the horizontal at a speed of 10 m/s. Air resistance is negligible. [10 marks]

    (a) What are the horizontal and vertical velocities of the ball when it leaves the ground?

    $v_x = v_0 \cos(40°) = 7.66m/s$
    $v_y = v_0 \sin(40°) = 6.43m/s$

    (b) What is the time of flight of the ball?

    $t_f = 2v_{0y}/g = 1.31s$

    (c) What is the maximum height of the ball?

    $h = v_{0y}^2/2g = 2.12m$

    (d) What is the maximum width of the river that allows Bob to kick it across to Chris without the ball falling into the water?

    $w = v_{0x}t = 10.03m$

    (e) Now Chris wants to kick the ball back to Bob, but it gets caught in a bush on the river's edge 0.4 m above the ground. What are the possible horizontal distances between Chris and the bush?

    $y = y_0 + v_{0y}t - 0.5gt^2 = 0.4m$
    $0.5gt^2 - v_{0y}t + 0.4m = 0$
    $t_{1,2} = \frac{v_{0y} \pm \sqrt{v_{0y}^2 - 4 \cdot (g/2) \cdot 0.4}}{g}$
    $t_1 = 1.24s$
    $t_2 = 0.06s$
    $x_1 = 9.50m$
    $x_2 = 0.46m$

Text

13. A bowling ball is rolled with the following velocity vector: $\vec{v}_1 = (2.45\text{ m/s})\,\hat{\imath} + (3.67\text{ m/s})\,\hat{\jmath}$. [10 marks]

    (a) Find the speed and angle of travel of the ball with respect to the positive x axis.

$$|\vec{v}| = \sqrt{v_x^2 + v_y^2} = \sqrt{2.45^2 + 3.67^2} = 4.42\text{ m/s}^2$$

$$\text{angle } \theta = \arctan\left(\frac{v_y}{v_x}\right) = \arctan\left(\frac{3.67}{2.45}\right) = 56.3^\circ$$

    (b) Another bowling ball is rolled with velocity vector: $\vec{v}_2 = (-2.45\text{ m/s})\,\hat{\imath} + (5.50\text{ m/s})\,\hat{\jmath}$. Find the relative velocity of the second ball relative to the first. Express the answer in unit vector notation *and* in terms of magnitude and direction of the relative motion with respect to the x axis. (Hint: Find $\vec{v}_2 - \vec{v}_1$.) Taking heed of the hint:

$$\vec{v}_2 - \vec{v}_1 = (-2.45\text{ m/s})\,\hat{\imath} + (5.50\text{ m/s})\,\hat{\jmath} - (2.45\text{ m/s})\,\hat{\imath} - (3.67\text{ m/s})\,\hat{\jmath}$$

$$= (-2.45\text{ m/s} - 2.45\text{ m/s})\,\hat{\imath} + (5.50\text{ m/s} - 3.67\text{ m/s})\,\hat{\jmath}$$

$$= (-4.90\text{ m/s})\,\hat{\imath} + (1.83\text{ m/s})\,\hat{\jmath}$$

$$|\Delta\vec{v}| = \sqrt{\Delta v_x^2 + \Delta v_y^2} = 5.23\text{ m/s}$$

$$\text{angle } \theta = \arctan\left(\frac{1.83}{4.90}\right) = 20.5^\circ$$

14. The following histogram represents the grade distribution of the students in a physics class of 24 students. [10 marks]

    (a) Calculate the mean.

    $mean = (3 \cdot 55 + 5 \cdot 60 + 6 \cdot 65 + 8 \cdot 70 + 2 \cdot 75)/24 = (165 + 300 + 390 + 560 + 150)/24 = 65.21$

    (b) Calculate the standard deviation of the mean and show your work below.

    Residuals squared:
    $(65.21 - 55)^2 = 104.24$
    $(65.21 - 60)^2 = 27.14$
    $(65.21 - 65)^2 = 0.04$
    $(65.21 - 70)^2 = 22.94$
    $(65.21 - 75)^2 = 95.84$
    $sum = 3 \cdot 104.24 + 5 \cdot 27.14 + 6 \cdot 0.04 + 8 \cdot 22.94 + 2 \cdot 95.84 = 823.86$
    $SD = \sqrt{823.86/23} = 5.98$
    $SDM = SD/\sqrt{24} = 1.22$