# Exam 1, Version B, Phys 114A, Spring 2001

*You do not need to turn in these sheets.*

*You have to make sure that your neighbor to the left and right have a different version of the test (a different color).*

*Please note that if a problem is deemed to have an increased level of difficulty then the corresponding problem "might" be marked with a star *. However, all problems have an equal weight and whether you solve a "difficult" problem or an "easy" one, you still get only one point for the corresponding problem.*

*In each of the following problems determine which one of the numerical answers provided is either the correct one or the closest to the correct answer and then mark correspondingly the bubble sheet.*

*Reminder: you are allowed only one sheet of handwritten notes, a calculator, eraser, pencil and pen. Scratch paper will be provided.*

1. A typical Olympic 100 meter participant covers the distance in 10 seconds. Let us assume that during the first 2 seconds he was moving with constant acceleration and in the subsequent 8 seconds he was running with constant speed and also that a typical mass of such a runner is 80 kg. What is the magnitude of the force exerted by him on the ground to generate the required acceleration, assuming that there is no air resistance.

a) 435 N; b) 440 N; c) 445 N; d) 455 N.

From

$$100 = a \times 2^2/2 + (a \times 2) \times 8,$$

where $a \times 2^2/2$ is the distance traveled during the first 2 seconds, $a \times 2$ is the speed at the end of the 2 seconds and $(a \times 2) \times 8$ is the distance traveled during the last 8 seconds, one obtaines that $a = 5.55\ m/s^2$ and thus $F = ma = 80 \times 5.55\ N = 444.44\ N$.

2. The coordinate of an object changes with time as $x = 5 + 3t + 2t^2$, where the unit for length is the meter and the unit for time is the second. What is the average velocity during the time interval from $t_1 = 2$ s to $t_2 = 5$ s?

a) 12.0 m/s; b) 17.0 m/s; c) 10.0 m/s; d) 15.0 s.

The average velocity is

$$v = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$$

where

$$x_1 = 5 + 3 \times 2 + 2 \times 2^2 = 19$$

$$x_2 = 5 + 3 \times 5 + 2 \times 5^2 = 70$$

and thus $v = 17$ m/s.

3. What is the magnitude of the force with which you pull a crate on the floor with constant velocity, if the mass of the crate is 45 kg, the coefficient of kinetic friction is $\mu_k = 0.15$ and the applied force makes a 35° angle with the horizontal?

a) 700 N; b) 73 N; c) 350 N; d) 81 N.

One can write the condition that the net force is vanishing in both horizontal and vertical directions, as there is no acceleration:

$$F \cos 35^\circ - \mu_k N = 0,$$

$$N + F \sin 35^\circ - mg = 0.$$

Substituting $N$ from the second equation into the first

$$F \cos 35^\circ - \mu_k (mg - F \sin 35^\circ) = 0$$

and solving for $F$ one obtains

$$F = \frac{\mu_k mg}{\cos 35^\circ + \mu_k \sin 35^\circ} = 73.078\ N$$

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4. On a cold and rainy day Bob decides to have a look at the world from the top of the roof of the house he lives in. The rainwater however has frozen and the roof is covered with a sheet of ice and Bob starts sliding down and eventually falls off the roof. The roof makes an angle of 20° with the horizontal, the edge of the roof is 4 m above the ground and, while on the roof, Bob slides a total distance of 5 m. Assuming no friction, how far from the house in the horizontal direction (from the edge of the roof) does Bob hit the ground?

a) 3.5 m b) 4.5 m c) 3.9 m d) 5.2 m.

The speed Bob attains at the end of his slide along the roof is

$$v_0 = \sqrt{2 \times 9.8 \times \sin(20^\circ) \times 5} = 5.789\ m/s.$$

He starts falling from the roof in a direction making 20° with horizontal, downward. From the condition that he falls from the roof in the vertical direction 4 meters, one determines the time

$$4 = v_0 \sin(20^\circ)t + \frac{gt^2}{2} \rightarrow t = 0.724\ s$$

I have chosen the positive direction downward in the vertical direction. Thus he will land at a distance

$$d = v_0 \cos(20^\circ)t = 3.94\ m$$

5. You fly a small airplane and want to get from city A to city B, which is 200 mi due South. There is an Westerly wind of 50 mph and your plane has an air speed (speed with respect to still air) of 150 mph. How long is your trip?

a) 1 hour and 15 minutes; b) 1 hour 25 minutes; c) 1 hour and 35 minutes; d) 1 hour and 30 minutes.

In order to fly directly South when the wind is blowing the pilot has to steer the plane slightly to the West. This velocity with respect to ground is then given by $\sqrt{150^2 - 50^2} = 141.42\ mph$. The wind velocity and his velocity with respect to ground make a right angle obviously and his velocity with respect to the air is the third side of this right triangle. He will thus have to fly for $200mi/141.42mph = 1.4142\ h$ =1 hour and 24.84 minutes.

6. A racing car covers the first qualifying lap with an average speed of 150 mph. In order to qualify for the race the racing car has to establish an average speed in two laps

of no less than 165 mph. What minimum average speed does the driver need to have in the second lap to qualify?

a) 170.5 mph; b) 180.5 mph; c) 177.3 mph; d) 183.3 mph.

Let the length of one lap be $d$, and $v_1$, $v_2$ and $v$ the avegare speeds for the first lap, second lap and for both laps respectively. From the condition that the total time of the race is the sum of the time spent on the first lap plus the time spent on the second lap

$$\frac{2d}{v} = \frac{d}{v_1} + \frac{d}{v_2}$$

since $d$ cancels, one gets that

$$\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2},$$

$$\frac{2}{165} = \frac{1}{150} + \frac{1}{v_2},$$

$$v_2 = 183.33\ mph$$

7. Kimberly stands on a bathroom scale in an elevator and notices that the scale shows her apparent mass to be 75 kg. As she weighted herself that same morning at home and knows that her "true" mass is 60 kg, she thus knows that the elevator has an acceleration and she can determine it. Assuming that the positive direction is chosen upward and she can determine correctly the absolute value and the direction of the acceleration, what value does she come up with?

a) 2.5 $m/s^2$; b) -2.5 $m/s^2$ ; c) 7.5 $m/s^2$; d) -7.5 $m/s^2$.

From the relation

$$N - mg = ma$$

where $N$ is the normal force exerted by the bathroom scale on Kimberly, and which is thus the apparent weight $N = m_a g$ (the force with which Kimberly presses on the scale) and $m_a = 75$ kg. One thus obtains that

$$a = \frac{N - mg}{m} = \frac{m_a - m}{m} g = 2.45\ m/s$$

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8. A pilot of a jet fighter plane flies at an altitude of 40 m above level ground at constant speed of 1500 km/h. At one point the terrain starts raising up at an angle of 6°. How much time does the pilot have to take corrective actions so as not run his plane into the ground?

a) 1.2 s;    b) 0.9 s;    c) 0.8 s;    d) 1.0 s.

The speed is $v$=1500 km/h= 416.67 m/s. If the pilot flies his airplane for a distance $d = vt$, such $d \tan 6° = 40$ m then he will run his plane into the ground. Thus he has $t = \frac{40m}{416.67m/s \times \tan 6°} = 0.91$ s to take avoding actions.

9. Jim beats Jeanette by 10 m in a 100 m dash. It is assumed that both of them cover this distance with a constant velocity. Jim wants to give Jeanette a fair advantage and thus agrees to start the race several meters behind the starting line. What would be a fair advantage for Jeanette?

a) 9.0 m;    b) 10.0 m;    c) 11.0 m;    d) 12.0 m.

In the first race one has

$$100 = v_{Jim} t_1 \qquad 90 = v_{Jeanette} t_1.$$

In the second race one has

$$100 + d = v_{Jim} t_2 \qquad 100 = v_{Jeanette} t_2$$

where $t_1$ and $t_2$ is the time of the first and second race respectively, and $d$ is the distance Jim stands back. By eliminating the times one obtains that

$$\frac{v_{Jim}}{v_{Jeanette}} = \frac{100}{90}$$

$$\frac{v_{Jim}}{v_{Jeanette}} = \frac{100 + d}{100}$$

thus

$$\frac{100}{90} = \frac{100 + d}{100}$$

and thus

$$d = \frac{100}{9} = 11.11 \ m$$

10. Richard is driving his car at 150 km/h when he passes a police officer traveling at 100 km/h. Assuming that the police officer can accelerate his motorcycle at 3 $m/s^2$ and that he starts the chase right when Richard is passing him and that Richard continues to drive his car at the same speed, determine at what distance from the passing point will the police officer catch up with Richard.

a) 200 m; b) 300 m; c) 400 m; d) 500 m.

Let $v_R = 150 \ km/h = 41.67 \ m/s$ and $v_0 = 100 \ km/h = 27.77 \ m/s$. Since Richard and the police officer travel the same distance from the point where Richard passed the police office to the point where the police office catches up with Richard, the diatnce is given by

$$d = v_R t = v_0 t + a t^2/2.$$

From $v_R t = v_0 t + a t^2/2$ one easily obtains that $v_R = v_0 + a t/2$, solving for $t = 2(v_R - v_0)/a = 9.25\ s$ and thus $d = v_R t = 385.80\ m$.