Phys104, Summer 2011, Exam 1

Student Name: Key **Seat Number:** ________ **Sequence Number: 101**

Honor Pledge and signature:

I have neither given nor received unauthorized aid on this examination. ____________________

Instructions:

This exam is closed book, closed notes. However, you may use a scientific calculator.
Mark your answers to the multiple-choice questions on a Scantron answer sheet.
For full credit, show all of your work on these test papers (no other scratch paper is allowed).
Each question is worth 3 points unless noted otherwise.
Ignore air resistance unless stated otherwise.

Equations and conversion factors that may be useful:

$x = x_o + v_{ox}t + \frac{1}{2}a_x t^2$ $\quad R = \frac{v_o^2 \sin 2\theta}{g}$ $\quad \Sigma \mathbf{F} = m\mathbf{a}$ $\quad 1\text{ m} = 3.28\text{ ft.}$

$v = v_o + at$ $\quad H = \frac{v_o^2 \sin^2 \theta}{2g}$ $\quad W \equiv mg$ $\quad 1\text{ lb.} = 4.45\text{ N}$

$v^2 = v_o^2 + 2ax$ $\quad f_s \le \mu_s F_n,\ f_k = \mu_k F_n$ $\quad g = 9.8\text{ m/s}^2$ $\quad R_{Earth} = 6.37\times10^6\text{ m}$

$c = 3.00\times10^8\text{ m/s}$ $\quad 1\text{ mi/h} = 1.61\text{ km/h} = 1.47\text{ ft/s} = 0.447\text{ m/s}$

% Correct | Discr. | Correl.

81% **1.** Your weight can be measured in kilograms: A. True (8) (B.) False (34) — Weight = force ≠ mass — 0.28 0.26

48% **2.** Evidence has been found of prehistoric dragonflies that are 10 times the size of typical dragonflies found today. If a modern dragonfly has a mass of about 5 g, what is the approximate mass of a giant ancient dragonfly? 0.23 0.23

15- A. 50 g
7- B. 500 g
20- (C.) 5000 g

Assuming similar density, $m \propto \text{Volume} \propto L^3$

$\therefore m' \propto 10^3 m = 1000 \cdot 5g = 5000g$

50% **3.** Estimate the weight of the air in this room (Phillips 215). Note: the density of air at STP is 1.29 kg/m^3. 0.23 0.13

14- A. 1.3 kN
21- (B) 13 kN
3- C. 130 kN
4- D. 1300 kN

$V \approx (12m)(8m)(13m) = 1200\ m^3 \pm 200\ m^3$

$M_{air} = \rho V = (1.29\ kg/m^3)(1200\ m^3) = 1500\ kg$

$F_g = mg = (1500 kg)(10 m/s^2) = 15\,000 N = 15 kN \sim 13 kN$

81% **4.** You drive at a constant speed of 20 m/s for 10 km and then 30 m/s for another 10 km. Your average speed is: 0.50 0.49

3- (A) 24 m/s
34- B. 25 m/s
8- C. 26 m/s

$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{20 km}{t_1 + t_2} = \frac{20 km}{833 s} = 24 m/s$

$t_1 = \frac{10 km}{20 m/s} = 500 s$

$t_2 = \frac{10 km}{30 m/s} = 333 s$

81% **5.** How far does light travel in one nanosecond? 0.63 0.43

4- A. 0.3 cm
2- B. 3.0 cm
34- (C) 30 cm
2- D. 3.0 m

$\Delta x = vt = ct = (3\times10^8 m/s)(1\times10^{-9} s) = 0.3 m = 30 cm$

71% **6.** Can an object be accelerating while maintaining a constant speed? (A) Yes (30) B. No (12) 0.50 0.34

Example: Uniform circular motion

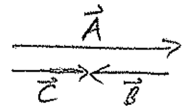
38% **7.** The force of friction acting on an object is always in the opposite direction of the object's motion. 0.05 0.13

A. True (30) (B.) False (12)

Example: Force on a box in bed of a pickup truck.

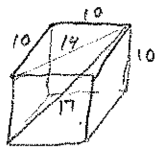
31% **8.** Vectors **A**, **B**, and **C** satisfy the vector equation **A** + **B** = **C**, and their magnitudes are related by the scalar equation A - B = C. What is the angle between vectors **A** and **B**? 0.60 0.50

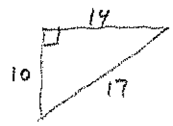
- 2 - A. 0
- 10 - B. 45°
- 17 - C. 90°
- 13 - (D) 180°



52% **9.** What is the greatest distance between any two points on a cube that has a volume of 1000 cm³? 0.65 0.44

- 7 - A. 10 cm
- 13 - B. 14 cm
- 22 - (C) 17 cm
- 0 - D. 100 cm





$L = \sqrt{1000} = 10\text{ cm}$

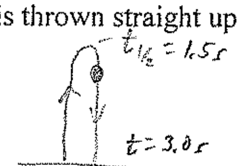
71% **10.** Find the acceleration of an object that is located at the following distances along the x-axis each second: 7 m, 13 m, 23 m, 37 m. 0.75 0.41

- 5 - A. 2 m/s²
- 30 - (B) 4 m/s²
- 6 - C. 8 m/s²
- 1 - D. 14 m/s²

t(s)	x(m)	v(m/s)	a(m/s²)
1	7		
2	13	6	4
3	23	10	4
4	37	14	

76% **11.** A baseball is thrown straight up and caught by the same hand 3.0 s later. How high did the ball go? 0.63 0.49

- 37 - (A) 11 m
- 5 - B. 22 m
- 4 - C. 44 m
- 1 - D. 88 m

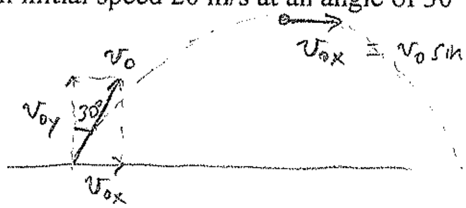


(same height)

$\Delta y = h = \frac{1}{2} g t_{1/2}^2 = \frac{1}{2}(9.8\text{ m/s}^2)(1.5\text{ s})^2 = 11\text{ m}$

55% **12.** A ball is thrown with initial speed 20 m/s at an angle of 30° with respect to vertical. What is its speed at the top of its flight path? 0.88 0.53

- 7 - A. 0
- 23 - (B) 10 m/s
- 2 - C. 20 m/s
- 10 - D. 17 m/s



$v_{0x} = v_0 \sin\theta = (20\text{ m/s})(\sin 30°) = 10\text{ m/s}$

88% **13.** A ball is thrown straight up in the air. At the top of its flight, 0.25 0.22

- 0 - A. its velocity is zero, and so is its acceleration
- 37 - (B) its velocity is zero, but it is still accelerating
- 3 - C. neither its velocity nor acceleration are zero
- 2 - D. none of the above

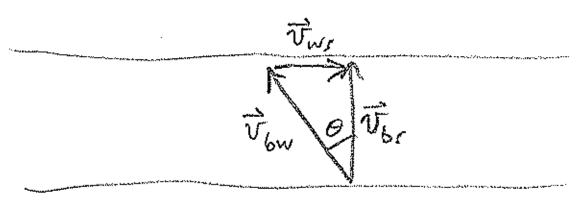
$v = 0, \quad a = -9.8\text{ m/s}^2$

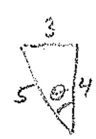
69% **14.** A rock is dropped at the same instant that a ball, at the same initial elevation, is thrown horizontally. Which will have the greater speed just before hitting the ground? 0.50 0.42

- 1 - A. The rock that was dropped
- 29 - (B) The ball that was thrown horizontally (not time)
- 12 - C. Neither, they both hit the ground at the same speed

55% **15.** A boat has a forward speed of 5 m/s relative to the water. At what angle should the driver of the boat head upstream in order to land directly across the river that has a current of 3 m/s? 0.40 0.38

- 1 - A. 20°
- 13 - B. 31°
- 23 - (C) 37°
- 5 - D. 59°





$\theta = \sin^{-1}\left(\frac{3}{5}\right) = 37°$

$\vec{v}_{bw} + \vec{v}_{ws} = \vec{v}_{bs}$

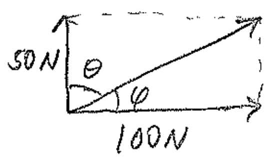
93% **16.** You are pushing a wooden crate across a concrete floor at a constant speed, when you decide that it might be easier to push the crate if you turn it up on its end so that only half of the original surface area is in contact with the floor. The force required to push the crate in this new orientation (compared to before) is about: 0.02 0.10

39 - (A) The same as before
0 - B. Twice as much as before
2 - C. Half as much as before
1 - D. One-fourth as much as before

Frictional force is (mostly) independent of surface area.

74% **(17)** Two friends pull you in different directions. One friend pulls with a force of 100 N to the east, and the other friend pulls with a force of 50 N to the north. What is the net force that causes you to accelerate? 0.75 0.61

3 - A. 150 N at an angle of 63° east of north
1 - B. 150 N at an angle of 63° north of east
31 - (C) 112 N at an angle of 63° east of north
7 - D. 112 N at an angle of 63° north of east



$F_{net} = \sqrt{100^2 + 50^2} = 112N$

$\theta = \tan^{-1}\left(\frac{100}{50}\right) = 63°$ or $\varphi = 27°$

64% **(18)** A big truck collides with a small car. Which experiences a greater force? 0.53 0.39

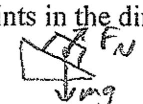
0 - A. The truck
9 - B. The car
26 - (C) Both experience the same force
6 - D. There is not enough information to determine

Newton's 3rd law: $\vec{F}_{ct} = -\vec{F}_{tc}$

90% **19.** The normal force acting on an object always points in the direction opposite the weight vector. 0.25 0.33

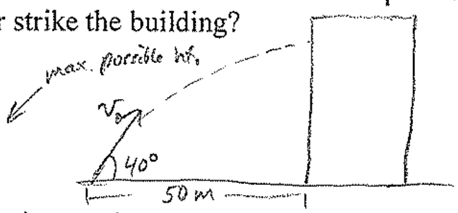
A. True 4 (B) False 38

Example:



36% **(20)** A firefighter, 50 m away from a 12-story burning building, directs a stream of water from a ground-level hose at an angle of 40° above horizontal. If the speed of the stream as it leaves the hose is 40 m/s, at what height does the water strike the building? 0.65 0.51

1 - A. 24 m
15 - (B) 29 m
19 - C. 34 m
7 - D. 42 m



$x = V_{0x} t$ or $t = \frac{x}{V_{0x}} = \frac{50\ m}{(40\ m/s)\cos 40°} = 1.63s$

$y = V_{0y} t - \frac{1}{2} g t^2$

$= (40\ m/s)(\sin 40°)(1.63s) - \frac{1}{2}(9.8\ m/s^2)(1.63s)^2 = 29\ m$

41.9 m - 13.0 m

48% **21.** A woman in a stationary elevator weighs 600 N. As the elevator travels from the 1st to the 6th floor, it decreases its upward speed from 8 to 2 m/s in 3 s. What is the average force exerted by the elevator floor on the woman during this 3-second time interval? -0.15 0.17

20 - (A) 480 N
3 - B. 560 N
0 - C. 600 N
19 - D. 720 N

$F_n - mg = ma$ $a = \frac{\Delta v}{\Delta t} = \frac{2\ m/s - 8\ m/s}{3s} = -2\ m/s^2 = 0.2g$ $m = \frac{600N}{10\ m/s^2} = 60kg$

$\therefore F_n = mg + ma = 600N + (60kg)(-2\ m/s^2) = 480N$ (she feels ~20% lighter)

50% **(22)** Why do the astronauts on the International Space Station feel weightless? 0.43 0.40

21 - (A) they are in free-fall around the Earth
18 - B. there is no gravity in space, so mg = 0
3 - C. the rockets on the spacecraft accelerate the craft at a = g
0 - D. because there is no atmosphere

41% **23.** A car with a mass of 1500 kg is traveling along a level road when the driver sees a red light and slams on the brakes to come to a screeching stop. What was the car's initial speed if the skid marks left by the car are 40 m long? (The coefficient of static friction between the tires and dry asphalt is about 1.0 and the coefficient of kinetic friction is about 0.8). 0.35 0.23

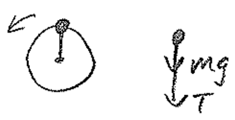
4 - A. 20 m/s
17 - (B) 25 m/s
11 - C. 28 m/s
9 - D. There is not enough information to answer this question

$V_0 = \sqrt{2ax}$ $F_{net} = F_f = \mu_k mg = ma$ $\therefore a = \mu_k g$

$V_0 = \sqrt{2\mu_k g x} = \sqrt{2(0.8)(10\ m/s^2)(40m)} = 25\ m/s$

33% **24.** For a ball swung in a vertical circular path, which of the following equations is a proper application of Newton's second law when the ball is at the top of its circular path? (T is the tension force.) 0.33 0.39

14- (A) $T + mg = ma$
19- B. $T - mg = ma$
7- C. $T - mg = -ma$
2- D. $-T - mg = ma$



$F_{net} = -mg - T = -ma$

or $T + mg = ma$

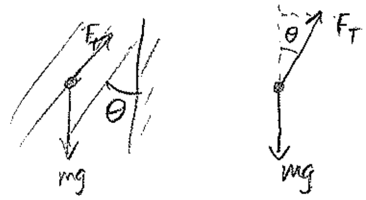
76% **25.** A tug of war is held between two teams of five men each. If each man pulls with an average force of 500 N, what is the tension in the middle of the rope? 0.05 0.06

1- A. 0
32- (B) 2500 N
9- C. 5000 N

5×500N   5×500N = 2500N

56% **(26).** While riding in an airplane, you notice that during takeoff, the curtains that were hanging straight down now make an angle of 30° from vertical. What is the acceleration of the plane? 0.65 0.48

3- A. 3.3 m/s^2
16- B. 4.9 m/s^2
23- (C) 5.7 m/s^2
4- D. 9.8 m/s^2

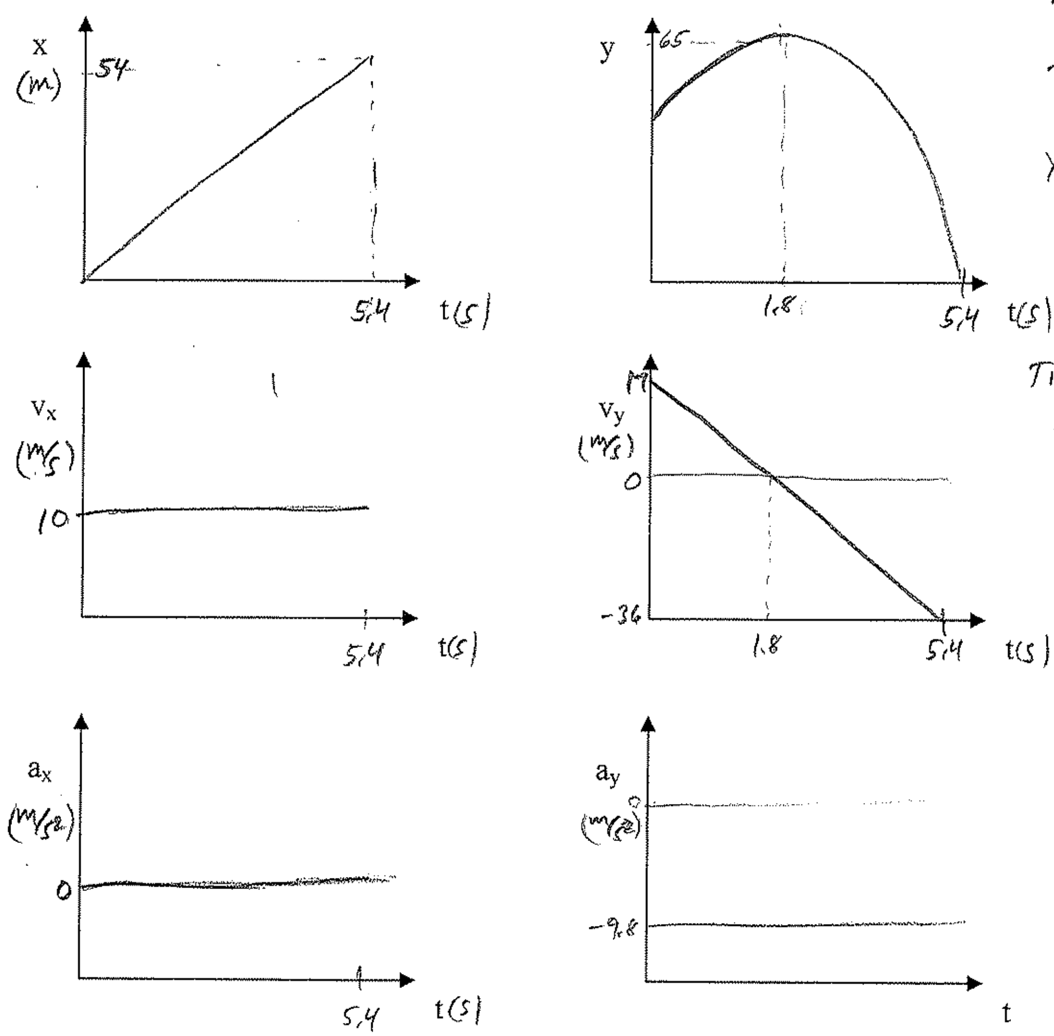


$F_T \sin\theta = ma$

$F_T \cos\theta = mg$

$\therefore \tan\theta = \frac{a}{g}$ or $a = g\tan\theta = 5.7\ m/s^2$

27. (22 points) A rock is thrown with an initial speed of 20 m/s at an angle of 60 degrees above horizontal off the edge of a cliff that is 50 m high. Sketch the graphs of vertical and horizontal displacement, velocity, and acceleration as functions of time. Be sure to label the graphs to indicate the numerical values and units for any critical points during the flight of this rock. Show relevant calculations in the space to the right of the graphs.



$v_{0x} = v_0 \cos 60° = 10\ m/s$

$v_{0y} = v_0 \sin 60° = 17.3\ m/s$

$y_{max} = \frac{v_{0y}^2}{2g} = \frac{(17.3\ m/s)^2}{2(9.8\ m/s^2)}$

$y_{max} = 15.3\ m$ (above launch pt)

Time to y_{max}:

$t_1 = \frac{v_{0y}}{g} = \frac{17\ m/s}{9.8\ m/s^2} = 1.77\ s$

check: $t_1 = \sqrt{\frac{2y}{g}} = 1.77\ s$ ✓

Time from y_{max} to y_f:

$y = 50\ m + 15.3\ m = 65.3\ m$

$t_2 = \sqrt{\frac{2(65.3\ m)}{9.8\ m/s^2}} = 3.65\ s$

$t = t_1 + t_2 = 5.42\ s$

$v_{yf} = g t_2 = (-9.8\ m/s^2)(3.65\ s)$

$v_{yf} = -35.8\ m/s$

$x = v_x t = (10\ m/s)(5.4\ s) = 54\ m$