KR = 0.71 Mean = 59% SD = 16% High = 85% Low = 25%

Phys24-001, Fall 2001 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 calculator.
Mark your answers to the multiple-choice questions on a Scantron answer sheet.
You may write on these test papers, but no partial credit will be given on the multiple-choice section.

Equations and conversion factors that may be useful:

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

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

$v^2 = v_o^2 + 2ax$ $f_s \le \mu_s n,\ f_k = \mu_k n$ $g = 9.8\,\text{m/s}^2$ $v_{\text{sound in air}} \approx 340\,\text{m/s}$

1 mi/h = 1.61 km/h = 1.47 ft/s = 0.447 m/s

Discrimination / Biserial correl.

85% 1. (5) Which of the following is equivalent to the prefix T for "tera" or one trillion: 0.42 0.46

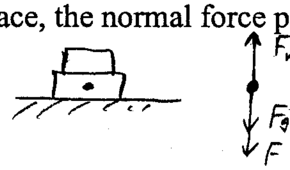
0 – 1. 10^6
5 – 2. 10^9
47 – (3.) 10^{12}
3 – 4. 10^{15}

95% 2. (4) If an object has zero acceleration, then it must be at rest. 1. True (3) (2.) False (52) 0.25 0.43

No acceleration could mean constant velocity.

60% (11%) 2000 3. (1) Whenever an object is resting on a horizontal surface, the normal force pushing up on the object is equal to its weight. 0.75 0.48

1. True (20) (2.) False (33) Counter-example:



$F_n > F_g$

93% 4. (6) Which of the following is NOT an assumption for projectile motion: 0.33 0.46

Class Notes

51 – (1.) There are no forces acting on the projectile.
2 – 2. The acceleration due to gravity (g) is constant over the range of motion
0 – 3. The effect of air resistance is negligible
1 – 4. The rotation of the Earth does not affect the motion.

The only force acting on an object that exhibits projectile motion is the force due to gravity, F_g

$\downarrow F_g = mg$

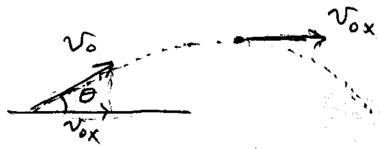
Avg. of questions 1–10: 72%.
Avg. of questions 11–20: 47%

Name: ______________

(2)
(5.) A ball is thrown with initial speed v_o at an angle θ with respect to the ground. What is its speed at the top of its flight path?

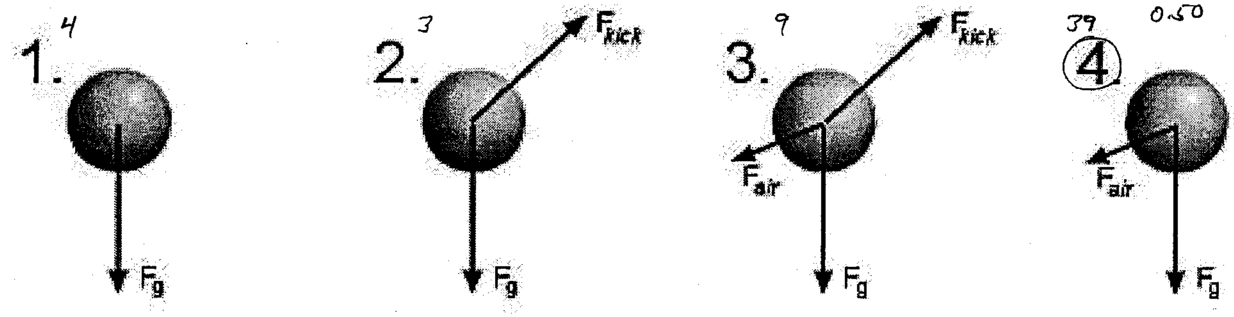
31%   0.83   0.61

17- (1.) $v = v_o\cos\theta$
12- 2. $v = v_o\sin\theta$
17- 3. $v = v_o\cos\theta - gt$
8- 4. $v = v_o - gt$
5. $v = v_o \sin\theta - gt$



(3)
71% 6. Which of the following is the correct free-body diagram for a football AFTER it has been kicked?   0.50   0.37

Class Notes



(1)
84% 7. A ball is thrown straight up in the air. At the top of its flight,   0.42   0.52

HW2a

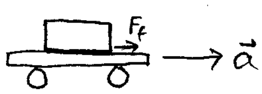
5- 1. its velocity is zero, and so is its acceleration
46- (2) its velocity is zero, but it is still accelerating
2- 3. neither its velocity nor acceleration are zero
2- 4. none of the above

(8)
51% 8. The force of friction acting on an object is always in the opposite direction of the object's motion.   0.58   0.33

HW4a

1. True   (2.) False
27   28

Example:



A box on a flatbed truck moves forward because of the frictional force that is in the same direction as $\vec{a}$.

(10)
76% 9. 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: 0.50   0.50

(41%) 2000

Class Notes

1- 1. Twice as great
42- (2.) Equally great
10- 3. Half as great
2- 4. One-fourth as great

$F_f = \mu F_n$ (independent of surface area)

(9)
69% 10. Two cars are traveling at the same speed on a level road when their drivers see a red light and slam on the brakes to come to a screeching halt. Both cars are similar in design, but car A has twice the mass of car B. Which car stops first?   0.42   0.32

(23%) 2000

3- 1. Car A
13- 2. Car B
38- (3) Both cars stop at the same time
1- 4. More information is needed to answer this question

$F_{net} = ma$

$F_{net} = F_f = \mu_k F_n = \mu_k mg$

$\therefore \mu_k mg = ma$

$a = \mu_k g$

Both cars have the same acceleration (if same μ_k).

$\therefore$ Both stop in the same time and distance.

Name: ____________________

(12)
95% 11. Estimate the number of times your heart beats each year: 0.25 0.41

Class Notes

- 0 - 1. 3×10^6
- 52 - (2) 3×10^7
- 2 - 3. 3×10^8
- 1 - 4. 3×10^9

Typical heart rate ≈ 60 beats/min = 1 Hz

$$N = \left(1 \frac{\text{beat}}{\text{sec}}\right)\left(\frac{60\ \text{sec}}{\text{min}}\right)\left(\frac{60\ \text{min}}{\text{hr}}\right)\left(\frac{24\ \text{hr}}{\text{day}}\right)\left(\frac{365\ \text{days}}{\text{yr}}\right) = 3 \times 10^7\ \text{beats/year}$$

Shortcut: $1\ \text{yr} \approx \pi \times 10^7\ \text{sec}$

(13)
42% 12. Estimate the weight of the air in this room. (Hint: density of air at STP is 1.29 kg/m^3) 0.50 0.31

Class Notes (water drop)

- 10 - 1. 1.3 kN $(4.6\text{m})^3$
- 23 - (2) 13 kN $(10\text{m})^3$
- 16 - 3. 130 kN $(22\text{m})^3$
- 5 - 4. 1300 kN
- 1 -

Dimensions of room ≈ 10 m × 10 m × 10 m = 1000 m^3

$\rho = \frac{m}{V}$ so $m = \rho V = (1.29\ \text{kg/m}^3)(1000\ \text{m}^3) = 1290\ \text{kg}$

$F_g = mg = (1290\ \text{kg})(9.8\ \text{m/s}^2) = 1.26 \times 10^4\ \text{N} \approx 13\ \text{kN}$

24% (13) What is the approximate weight of a mother elephant that is twice the height of her baby which weighs 500 pounds? 0.42 0.36

UWC Ram

- 15 - 1. 1000 lbs
- 27 - 2. 2000 lbs
- 13 - (3) 4000 lbs
- 0 - 4. 8000 lbs

$W \propto V \propto x^3$

∴ The weight of a 3-dimensional object scales as x^3.

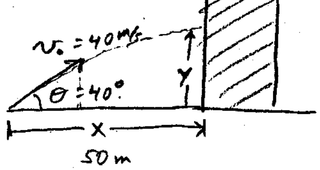
$$\frac{W_m}{W_b} = \frac{h_m^3}{h_b^3} = \frac{(2h_b)^3}{h_b^3} = 8 \quad \text{so } W_m = 8W_b = 8(500\ \text{lbs}) = 4000\ \text{lbs}$$

Example: Child is 3' tall, 30 lbs; Father is 6' tall, 240 lbs

(17)
60% (31%) 2000 14. 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? 0.75 0.60

Class Notes

- 4 - 1. 24 m
- 33 - (2) 29 m
- 10 - 3. 34 m
- 8 - 4. 42 m



$x = v_{0x} t \Rightarrow t = \frac{x}{v_{0x}} = \frac{50\ \text{m}}{(40\ \text{m/s})\cos 40°} = 1.632\ \text{s}$

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

$y = (40\ \text{m/s})(\sin 40°)(1.632\ \text{s}) - \frac{1}{2}(9.8\ \text{m/s}^2)(1.632\ \text{s})^2$

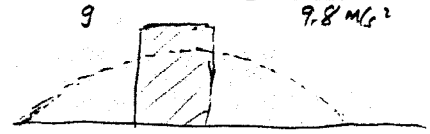
$y = 29\ \text{m}$

(18)
13% (9%) 2000 (15) What is the maximum height of the water from the firefighter's hose in the previous problem? 0.42 0.40

- 1 - 1. 24 m
- 7 - (2) 29 m
- 32 - 3. 34 m
- 15 - 4. 42 m

Does the water reach its maximum height before hitting the building?

$R = \frac{v_0^2 \sin 2\theta}{g} = \frac{(40\ \text{m/s})^2 \sin(80°)}{9.8\ \text{m/s}^2} \approx 158\ \text{m}$ No, $x = 50\ \text{m} < \frac{R}{2} = 79\ \text{m}$



(16)
31% (22%) 2000 16. A woman in a stationary elevator weighs 700 N. As the elevator travels from the 1$^{\text{st}}$ to the 6$^{\text{th}}$ 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? 0.50 0.43

- 9 - 1. 350 N
- 17 - (2) 560 N
- 9 - 3. 700 N
- 19 - 4. 840 N

$\Sigma F = ma$

$F_n - mg = ma$

$a = \frac{\Delta v}{\Delta t} = \frac{2\ \text{m/s} - 8\ \text{m/s}}{3\ \text{s}} = -2\ \text{m/s}^2$

∴ $F_n = 700\ \text{N} + (70\ \text{kg})(-2\ \text{m/s}^2) = 700\ \text{N} - 140\ \text{N} = 560\ \text{N}$

You feel lighter riding in an upward-moving elevator that is slowing down.

28% (19) 17. 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?

P4.58
3 - 1. 3.3 m/s^2
25 - 2. 4.9 m/s^2
15 - (3) 5.7 m/s^2
11 - 4. 9.8 m/s^2

$\Sigma F = T\sin\theta = ma$ $\quad T\cos\theta = mg$ $\quad \therefore T = \frac{mg}{\cos\theta}$

$\frac{mg}{\cos\theta}\sin\theta = ma$

$\therefore a = g\tan\theta = (9.8\ m/s^2)(\tan 30°) = 5.7\ m/s^2$

71% (14) 18. A sports car is reportedly capable of accelerating from 0 to 60 mi/h in 4.4 seconds. What is the average acceleration of this car?

Class Notes
39 - (1) 6.1 m/s^2 = 0.6g
14 - 2. 14 m/s^2 = 2g
2 - 3. 6.8 m/s^2 = 0.7g
0 - 4. 9.8 m/s^2 = 1g

$60\ mi/h = (60\ \frac{mi}{h})(0.447\ \frac{m/s}{mi/h}) = 26.8\ m/s$

$a = \frac{\Delta v}{\Delta t} = \frac{26.8\ m/s}{4.4\ s} = 6.1\ m/s^2$

58% (63%) (20) 19. 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).

2000 RWP4
4 - 1. 20 m/s
31 - (2) 25 m/s
14 - 3. 28 m/s
4 - 4. There is not enough information to answer this question

$\Sigma F = F_f = \mu_k mg = ma \quad \therefore a = \mu_k g$

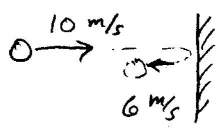
$v_f^2 = v_0^2 + 2ax$

$\therefore v_0 = \sqrt{2\mu_k g x} = \sqrt{2(0.8)(9.8)(40\ m)}$

$v_0 = 25\ m/s$

51% (15) 20. A 50-g tennis ball is thrown with a speed of 10 m/s directly at a wall and rebounds with a speed of 6 m/s. If the ball is in contact with the wall for 0.02 s, what average force does the wall exert on the ball?

HW26
14 - 1. 10 N
27 - (2) 40 N
7 - 3. 10 kN
5 - 4. 40 kN



$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} = \frac{-6\ m/s - 10\ m/s}{0.02\ s} = 800\ m/s^2$

$F = ma = (0.050\ kg)(800\ m/s^2) = 40\ N$

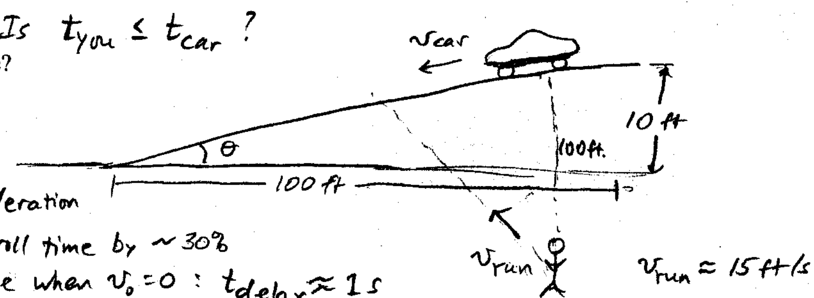
Real-world Problem (15 points)

Write your solution to the following problem using the GOAL problem-solving template that is provided.

After a long day, you drive home and park your car in the driveway. As you walk to the front door, you hear a sound behind you. When you turn around, you see your car starting to roll back down the driveway - evidently the car popped out of gear and is now coasting down the hill! Luckily, the driveway is rather long (about 100 feet), but you are currently about that same distance away on the right side of the car. You estimate that the bottom of the driveway is about 10 feet below the top elevation. Will you be able to run to the car and apply the brake before the car rolls out into traffic? (Assume that the car is unlocked and that you will not spend time trying to solve this problem before running to catch the car!)

Name: Key

Gather information: (4 points)
What is known? What are you looking for? *Is $t_{you} \le t_{car}$?*
What assumptions or estimations must be made?
Draw a diagram with variables labeled.
Predict a reasonable answer.



Assumptions + estimations:

- Assume const. slope → const. acceleration
- Estimate that friction increases roll time by ~30%
- Assume minimal delay from time when $v_0 = 0$: $t_{delay} \approx 1s$
- Air resistance is negligible for this situation.
- The time to get in and stop the car is: $t_{get\ in} \approx 2s$

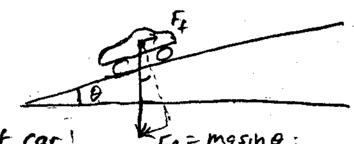
$v_{run} \approx 15\ ft/s$
$X_{run} \approx 120\ ft$

Prediction: It seems possible that the car can be stopped in time, but it may be close!

Organize your approach: (2 points)
Classify the problem. Describe how you will solve it.

This is primarily a kinematics problem, but we need Newton's 2nd law, F=ma, to find the acceleration of the car as it rolls down the hill. Friction must also be considered in determining the car's acceleration.

Analyze the problem: (4 points)
Identify and show relevant physics equations. Account for real-world effects.
Solve algebraically. Substitute known values, calculate answer, round appropriately.



Is $t_{you} \le t_{car}$?

$t_{you} = t_{run} + t_{get\ in}$

$t_{run} = \frac{X_{run}}{v_{run}} \approx \frac{120\ ft}{15\ ft/s} = 8\ sec$

$\therefore t_{you} \approx 8s + 2s = 10\ sec$

Acceleration of car: $F_p = mg\sin\theta$:

$\Sigma F = F_p - F_f = ma$

Estimate frictional force from minimum angle θ at which a car will just start to roll: $\theta_{min} \approx 3°$

$\therefore mg\sin\theta - mg\sin 5° = ma$

$a = (32\ ft/s^2)\left(\frac{10\ ft}{100\ ft}\right) - (32\ ft/s^2)(0.05) = 1.6\ ft/s^2$

$X_{car} = \frac{1}{2} a t_{car}^2$, so $t_{car} = \sqrt{\frac{2X_{car}}{a}} = \sqrt{\frac{2(100\ ft)}{1.6\ ft/s^2}} = 11\ sec$

$v_f = a t_{car} = 1.6\ ft/s^2 (11s)$

$v_f = 18\ ft/s$

Learn from your efforts: (5 points)
Does the answer agree with the prediction? Correct units?
Does the solution account for all the real-world factors that should be considered?
What else can be learned from this problem?

With the above assumptions, it appears that there is just barely enough time to get to the car and apply the brake. However, by this time, the car will be moving at about 18 ft/s (which is the speed of a fast run), and another ~1 sec and ~10 ft will be required to fully stop the car. With slightly different assumptions, it is quite likely that the car cannot be stopped in time.

Grading notes:

Reasonable values:

v_{run} = 10 ft/s to 20 ft/s
t_{delay} = 0.5 s to 5 sec
$t_{get\ in}$ = 1 sec to 5 sec
X_{run} = 110 ft to 150 ft.

$\therefore t_{you}$ = 7s to 20s

Friction effect: $\theta_{min} \approx 1°$ to $5°$
$\therefore a_{car}$ = 0.4 ft/s² to 3 ft/s²
$\therefore t_{car}$ = 8s to 22s