PHYS 124 Section A1
Mid-Term Examination
Spring 2006

SOLUTIONS

Name_____

Student ID Number_____

Instructor Marc de Montigny
Date Monday, May 15, 2006
Duration 60 minutes

Instructions

- Items allowed: pen or pencil, calculator (programmable and graphic calculators are allowed). Personal digital assistants not allowed.
- Please turn off you cell phones.
- This is a closed book exam. A formula sheet is provided with the exam.
- The exam is worth a **total of 60 marks.**
- There are **10 short questions**. Each is worth 2 marks, for a **total of 20 marks**. No partial marks are allowed. Select the one best answer.
- There are **4 problems**. They are worth a **total of 40 marks**. Partial marks will be given. Show all work clearly and neatly.
- You may use the back of the pages for your own calculations. These will not be marked.

Short questions (Total of 20 marks). Circle the one best answer.

S-1. (2 marks) A *fathom* is a unit of length equal to six feet (1.83 meters) used especially for measuring the depth of water. Assuming that the distance to the Moon is about 4×10^8 m, the distance to the Moon in fathoms is about

A. 4×10^8 fathoms

B. 2×10^8 fathoms

C. 3×10^8 fathoms

D. 8×10^8 fathoms

S-2. (2 marks) Which of the following relationships is dimensionally consistent with an expression yielding a value for acceleration? In these equations, x is a distance, t is time, and v is velocity.

A. v/t^2

B. v/x^2

C. v^2/t

D. v^2/x

S-3. (2 marks) Four forces act on an object. They are given by **A** = 40 N east, **B** = 50 N north, **C** = 70 N west, and **D** = 90 N south. What is the magnitude of the net force on the object?

A. 50 N B. 131 N C. 170 N D. 250 N

E. not enough information given

S-4. (2 marks) An x versus t graph is drawn for a ball moving in one direction. The graph starts at the origin, increases with a positive slope for five seconds, and then levels off to a zero slope for 2 s. We can be sure that

A. the speed is decreasing during the first 5 s.

B. the acceleration is constant throughout the complete motion.

C. **the speed is zero between $t=5$ s and $t=7$ s**.

D. the displacement is zero throughout the motion.

E. more than one of the above is true.

S-5. (2 marks) A ball is thrown straight up. For which situation are both the instantaneous velocity and the acceleration equal to zero?

A. on the way up

B. at the top of the flight path

C. on the way down

D. none of the above

S-6. (2 marks) A block of mass 10 kg remains at rest on a hill inclined at an angle of 30° above the horizontal. Which one of the statements below is correct about the magnitude of the force of friction that acts on the mass?

A. It is larger than the weight of the block.

B. It is equal to the weight of the block.

C. It is greater that the component of the force of gravity down the plane.

D. It is less than the component of the force of gravity down the plane.

E. **It is equal to the component of the force of gravity down the plane**.

S-7. (2 marks) A hockey puck struck by a hockey stick is given an initial speed of 10 m/s. If the coefficient of kinetic friction between ice and puck is 0.10, how far will the puck slide before stopping?

A. 39 m B. 45 m **C. 51 m** D. 57 m

S-8. (2 marks) Superman circles the Earth at a radius of $2R$, where R is the radius of the Earth. He then moves to a radius of $4R$. The gravitational force on him at this second orbit as compared to the first orbit is

A. the same
B. twice as great
C. four times as great
D. half as great
E. one fourth as great

S-9. (2 marks) When a car rides around a flat circular racetrack, the centripetal force is the

A. normal force
B. **static friction**
C. tension
D. kinetic friction
E. gravity

S-10. (2 marks) A 0.40 kg object is swung in a circular path and in a vertical place on a 50 cm length string. If a constant speed of 4 m/s is maintained, what is the tension in the string when the object is at the top of the circle?

A. 8.88 N B. 10.5 N C. 12.8 N D. 19.6 N

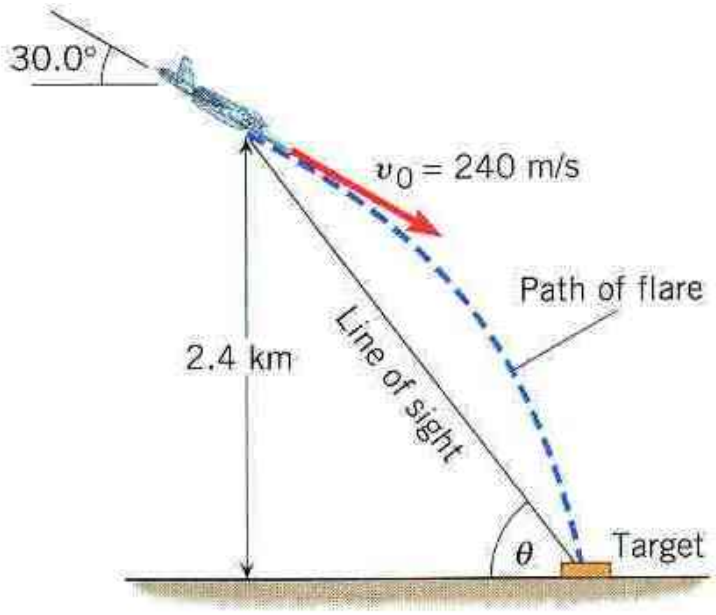
Problems (Total of 40 marks). Show all your work and be totally clear.

P-1. (10 marks) Equations of Kinematics for Constant Acceleration

An airplane is flying with a velocity of 240 m/s at an angle of 30° with the horizontal, as shown below. When the altitude of the plane is 2.4 km, a flare is released from the plane. The flare hits the target on the ground.

A. How long does it take the flare to reach the ground? **(5 marks)**

B. What is the angle θ? **(5 marks)**



Solution

A. $y = 2400 - (240\sin 30)t - 4.9t^2 = 0$ at t = -37.5 s and 13.048 s. We keep 13.0 sec

B. $x = (240\cos 30)(13.048) = 2712$ m, so that

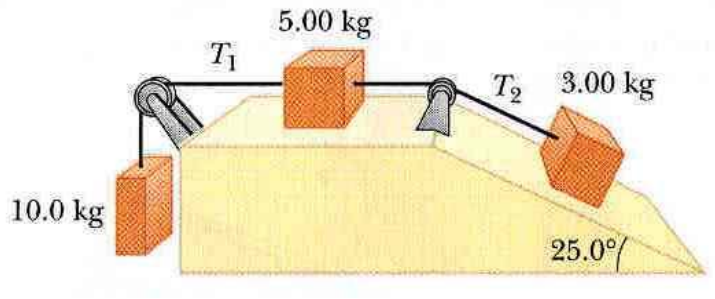
$\tan\theta = \dfrac{y}{x} = \dfrac{2400}{2712}$ from which we find $\theta = 41.5^o$

P-2. (15 marks) Newton's Laws of Motion

Three blocks of masses 10.0 kg, 5.0 kg and 3.0 kg are connected by two light strings that pass over frictionless pulleys as shown below. The acceleration of the 5.0 kg block is 2.0 m/s^2 to the left, and the surfaces are rough. The 10.0 kg block is moving downwards. Find:

A. the tension in each string **(5 marks)**

B. the coefficient of kinetic friction between blocks and surfaces. (Assume the same coefficient for both blocks in contact with surfaces.) **(10 marks)**



Solution

We use $\sum F_x = ma_x$ and $\sum F_y = ma_y$ for each block

10-kg block, x : trivial
10-kg block, y : $10g - T_1 = 10(2)$
(x-axis is horizontal)

5-kg block, x : $T_1 - T_2 - \mu_K (5g) = 5(2)$
5-kg block, y : $F_{N5} = 5g$
(x-axis is horizontal)

3-kg block, x : $T_2 - \mu_K (3g)\cos 25 - 3g \sin 25 = 3(2)$
3-kg block, y : $F_{N3} = 3g \cos 25$
(x-axis parallel to the plane)

These equations give $T_1 = 78$ N, $T_2 = 35.9$ N and $\mu_K = 0.655$

P-3. (5 marks) Newton's Third Law of Motion

Consider a horse attempting to pull a wagon from rest on a rough surface. A student who misunderstood Newton's third law makes the following statement: "If the horse pulls forward on the wagon, then Newton's law of action-reaction holds that the wagon pulls back equally hard on the horse. Thus, the forces cancel and the system cannot be set in motion."

Explain briefly what is incorrect with the statement of this student.

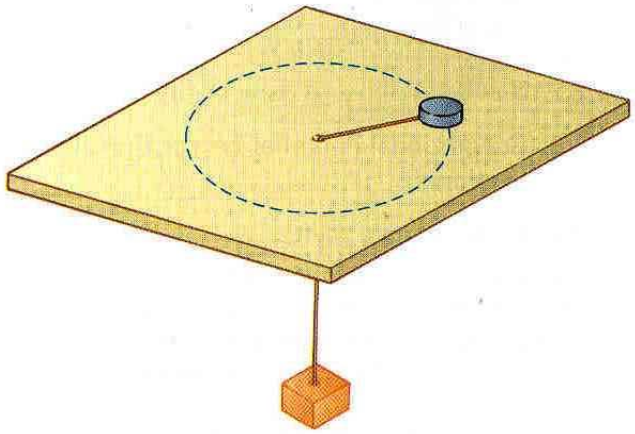
Solution

$\sum F = ma$ should be applied to one object at a time, whereas the forces mentioned here are applied on different objects. The force that accelerates de system horse-wagon is the force of the Earth on the horse feet.

P-4. (10 marks) Uniform Circular Motion

An air puck of mass 0.25 kg is tied to a string and allowed to revolve in a circle of radius 1.0 m on a frictionless horizontal table, as displayed below. The other end of the string passes through a hole in the centre of the table, and a mass of 1.0 kg is tied to it. The suspended mass remains in equilibrium while the puck on the tabletop revolves.

A. What is the tension in the string? **(4 marks)**
B. What is the force causing the centripetal acceleration of the puck? **(2 marks)**
C. What is the speed of the puck? **(4 marks)**



Solution

A. The 1-kg mass does not accelerate, so that $T = 1(g) = 9.8$ N

B. Tension

C. For the puck, Newton's second law gives $T = \frac{mv^2}{r} = \frac{(0.25)v^2}{(1)}$, from which we find $v = 6.26$ m/s.