UNIVERSITY OF MANITOBA

December 15, 2015
(1:30 PM – 4:30 PM)

FINAL EXAMINATION

(+ formula sheet)

DEPARTMENT & COURSE NO.: PHYS 1020

TIME: 3 hours

EXAMINATION: General Physics 1

EXAMINERS: W. Ens, K. Shamseddine, P. Zetner

All questions are of equal value. No marks are subtracted for wrong answers.
Record all answers on the computer score sheet provided. **USE PENCIL ONLY!** Black pen will look good but may not be read reliably by the scoring machine. **Mark only one answer for each question!** Select the answer which is closest to yours.
A formula sheet is provided for your use; you may **not** use your own formula sheet. Calculators of any type are allowed, but not devices that store text or that can communicate with other such devices.
An answer should NOT be considered to be incorrect if the number of significant figures does not match the significant figures supplied in the question.
Be sure your name and student number are printed on the score sheet and the student number correctly coded in the box at the top right-hand side of the sheet.

TABLE OF CONSTANTS

$G = 6.673\times10^{-11}\,m^3kg^{-1}s^{-2}$	Standard atmospheric pressure = 1.013×10^5 Pa
$g = 9.8$ m/s^2	Specific heat capacity of water = 4186 J/(kg C°)
$\rho_{water} = 10^3$ kg/m^3	Specific heat capacity of ice and steam = 2000 J/(kg C°)
Mass of the earth = 5.98×10^{24} kg	Latent heat of fusion of water, $L_f = 33.5\times10^4$ J/kg
Radius of the earth = 6.38×10^3 km	Latent heat of vaporization of water, $L_v = 22.6\times10^5$ J/kg

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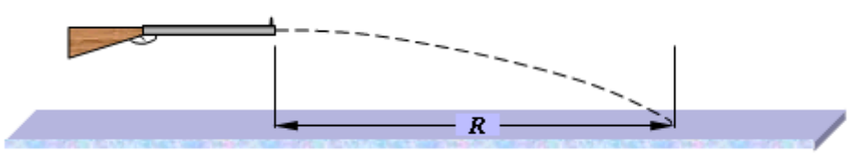
1. A turtle takes 3.5 minutes to walk 18 m toward the south along a deserted highway. A truck driver stops and picks up the turtle. The driver takes the turtle to a town 1.1 km to the north with an average speed of 12 m/s. What is the magnitude of the average velocity of the turtle for its entire journey?

   A) 3.6 m/s B) 9.8 m/s C) 6.0 m/s D) 2.6 m/s E) 11 m/s

2. A car travels due east at 22 m/s. It makes a turn due south and continues to travel at 22 m/s. What is the change in velocity of the car?

   A) 22 m/s, due east
   B) 22 m/s, due south
   C) 31 m/s, 45° south of west
   D) 31 m/s, 45° south of east
   E) zero m/s

3. A spring-loaded gun is aimed horizontally and is used to launch 2 identical balls. The gun is at a fixed position above the floor.



   If the speed of the second ball fired is twice the speed of the first ball fired, how is the horizontal range (denoted *R* in the figure) affected?

   A) The range for both balls will be the same.
   B) The range of the second ball will be half as much as that of the first ball.
   C) The range of the second ball will be twice as large as that of the first ball.
   D) The range of the second ball is about 1.4 times larger than that of the first ball.
   E) The range of the second ball will be smaller than that of the first ball by a factor of 1.4.

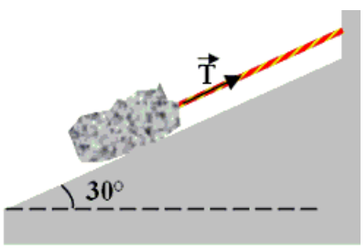
4. A marble is dropped straight down from a distance *h* above the floor.
Let F_m = the magnitude of the gravitational force *on the marble* due to the earth;
F_e = the magnitude of the gravitational force *on the earth* due to the marble;
a_m = the magnitude of the acceleration *of the marble* toward the earth;
a_e = the magnitude of the acceleration *of the earth* toward the marble.
Which set of conditions is true as the marble falls toward the earth? Neglect any effects of air resistance.

A) $F_m = F_e$ and $a_m < a_e$
B) $F_m < F_e$ and $a_m > a_e$
C) $F_m < F_e$ and $a_m = a_e$
D) $F_m > F_e$ and $a_m = a_e$
E) $F_m = F_e$ and $a_m > a_e$

5. The wheels of an automobile are locked as it slides to a stop from an initial speed of 30.0 m/s. If the coefficient of kinetic friction is 0.600 and the road is horizontal, approximately how long does it take the car to stop?

A) 4.22 s B) 5.10 s C) 8.75 s D) 10.4 s E) 15.3 s

6. A rope holds a 10-kg rock at rest on a *frictionless* inclined plane as shown. Determine the tension in the rope.



A) 9.8 N B) 20 N C) 49 N D) 85 N E) 98 N

7. An object weighs 10 N on the earth's surface. What is the weight of the object on a planet that has one tenth the earth's mass and one half the earth's radius?

A) 4 N B) 2 N C) 1 N D) 10 N E) 20 N

8. An artificial satellite in a circular orbit around the Sun has a period of 8 years. Determine the ratio of the satellite's orbital radius to that of the earth's orbital radius. Assume that the earth's orbit around the Sun is circular.

A) 1 B) 2 C) 4 D) 8 E) 23

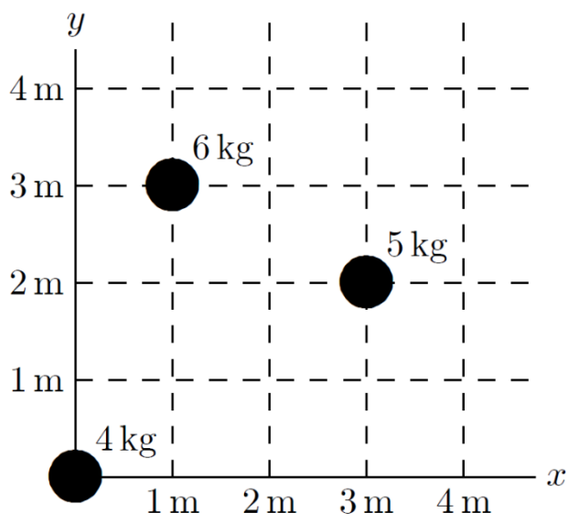
9. A pebble rolls off the roof of Science Hall and falls vertically. Just before it reaches the ground, the pebble's speed is 17 m/s. Neglect air resistance and determine the height of Science Hall.

A) 42 m B) 33 m C) 26 m D) 21 m E) 15 m

10. A dam is used to block the passage of a river and to generate electricity. Approximately 5.73×10^4 kg of water fall each second through a height of 19.6 m. If 85 % of the gravitational potential energy of the water were converted to electrical energy, how much power would be generated?

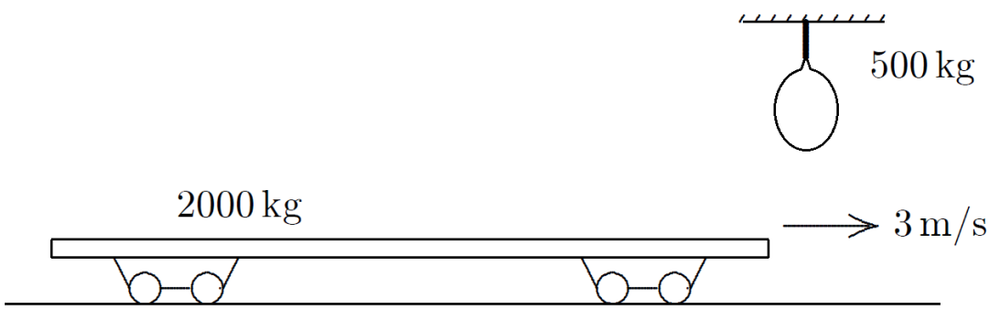
A) 9.36×10^6 W
B) 1.52×10^7 W
C) 1.08×10^7 W
D) 1.35×10^8 W
E) 4.68×10^6 W

11. The x and y coordinates of the center of mass of the three-particle system shown below are:



A) 0, 0 B) 1.3 m, 1.7 m C) 1.4 m, 1.9 m D) 1.9 m, 2.5 m E) 1.4 m, 2.5 m

12. A 500-kg sack of coal is dropped on a 2000-kg railroad flatcar which was initially moving at 3m/s as shown.



After the sack rests on the flatcar, the speed of the flatcar is:

A) 0.6 m/s B) 1.2 m/s C) 1.8 m/s D) 2.4 m/s E) 3.6 m/s

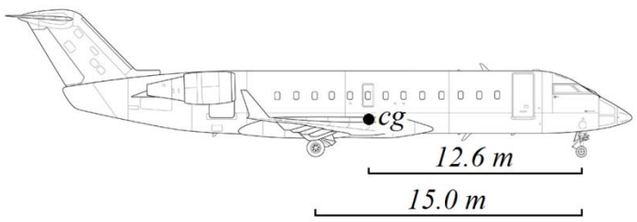
13. A 3-g bullet is fired horizontally into a 10-kg block of wood suspended by a rope from the ceiling. The block swings in an arc, rising 3mm above its lowest position. The velocity of the bullet was:

A) unknown since the heat generated in the collision was not given
B) 8.0×10^2 m/s
C) 24.0 m/s
D) 8.00 m/s
E) 2.4×10^4 m/s

14. A wind turbine is initially spinning at constant angular speed, ω_0. As the wind's strength gradually increases, the turbine experiences a constant angular acceleration of $\alpha = 0.140$ rad/s^2 . After making 2870 revolutions, its angular speed is $\omega = 137$ rad/s. How much time (in seconds) elapses while the turbine is speeding up?

A) 21 B) 50 C) 81 D) 110 E) 142

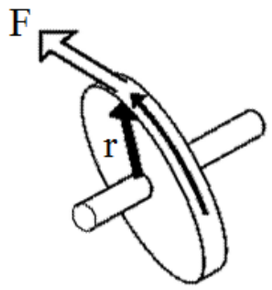
15. A jet transport has a weight of 1.00×10^6 N and is at rest on the runway. The two rear wheels are 15.0 m behind the front wheel, and the plane's center of gravity is 12.6 m behind the front wheel.



Determine the normal force exerted by the ground on the front wheel.

A) 1.00×10^6 N B) 5.00×10^5 N C) 3.20×10^5 N D) 1.60×10^5 N E) 1.00×10^5 N

16. A solid cylindrical disk has a radius of r = 0.15 m. It is mounted to an axle as shown.



When a 45 N force is applied tangentially to the disk, perpendicular to the radius, the disk acquires an angular acceleration of 120 rad/s^2 . What is the mass of the disk? (The moment of inertia of a solid cylindrical disk is $I = 1/2\ M\ r^2$.)

A) 300 kg B) 150 kg C) 5.0 kg D) 2.7 kg E) 0.4 kg

17. A thin rod has a length of 0.25 m and rotates in a circle on a frictionless tabletop. The axis is perpendicular to the length of the rod at one of its ends. The rod has an angular velocity of 0.32 rad/s and a moment of inertia of 1.1×10^{-3} kg.m^2 . A bug standing on the axis decides to crawl out to the other end of the rod. When the bug (mass = 4.2×10^{-3} kg) gets where it's going, what is the angular velocity of the rod (in rad/s)?

A) 0.26 B) 0.29 C) 0.32 D) 0.35 E) 0.38

18. A spring (k = 830 N/m) is hanging from the ceiling of an elevator, and a 5.0-kg object is attached to the lower end. By how much does the spring stretch (relative to its unstrained length) when the elevator is accelerating upward at a = 0.60 m/s^2?

A) 7.2×10^{-2} m B) 6.3×10^{-2} m C) 5.9×10^{-2} m D) 5.5×10^{-2} m E) 4.1×10^{-2} m

19. Objects of equal mass are oscillating up and down in simple harmonic motion on two different vertical springs. The spring constant of spring 1 is 174 N/m. The motion of the object on spring 1 has twice the amplitude as the motion of the object on spring 2. The magnitude of the maximum velocity is the same in each case. Find the spring constant of spring 2.

A) 174 N/m B) 435 N/m C) 696 N/m D) 957 N/m E) 1220 N/m

20. A spring is resting vertically on a table. A small box is dropped onto the top of the spring and compresses it. Suppose the spring has a spring constant of 450 N/m and the box has a mass of 1.5 kg. The speed of the box just before it makes contact with the spring is 0.49 m/s.
What is the magnitude of the spring's displacement when the spring is fully compressed?

A) 0 B) 1.2×10^{-2} m C) 3.3×10^{-2} m D) 5.5×10^{-2} m E) 7.6×10^{-2} m

21. A balloon inflated with helium gas (density = 0.2 kg/m^3) has a volume of 6×10^{-3} m^3. If the density of air is 1.3 kg/m^3, what is the buoyant force exerted on the balloon?

A) 0.01 N B) 0.08 N C) 0.8 N D) 1.3 N E) 7.8 N

22. When a block of volume 1.00×10^{-3} m^3 is hung from a spring scale as shown in Figure A, the scale reads 10.0 N. When the same block is then placed in an unknown liquid, it floats with 2/3 of its volume submerged as suggested in Figure B. The density of water is 1.00×10^3 kg/m^3.

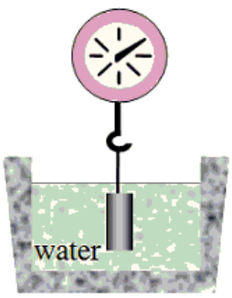


Figure A

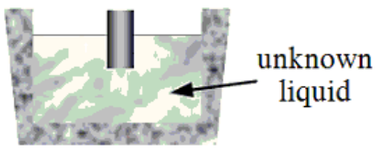
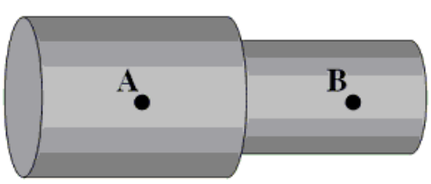


Figure B

Determine the density of the unknown liquid.

A) 3.03×10^3 kg/m^3
B) 4.62×10^3 kg/m^3
C) 6.16×10^3 kg/m^3
D) 8.01×10^3 kg/m^3
E) 1.57×10^4 kg/m^3

23. The density of the liquid flowing through the horizontal pipe in the drawing is 1200 kg/m^3. The speed of the fluid at point A is 7.5 m/s while at point B it is 11 m/s. What is the difference in pressure, $P_B - P_A$, between points B and A?

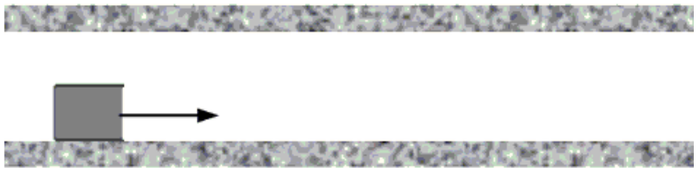


A) -1.9×10^3 Pa
B) $+3.8 \times 10^3$ Pa
C) -2.5×10^4 Pa
D) $+5.0 \times 10^4$ Pa
E) -3.9×10^4 Pa

24. At a certain temperature, a simple pendulum has a period of 1.500 seconds. The support wire is made of brass and has a coefficient of linear thermal expansion of 1.90×10^{-5}/Cº. How much must the temperature be increased to increase the period to 1.506 seconds?

A) 118 Cº B) 221 Cº C) 316 Cº D) 422 Cº E) 528 Cº

25. A 2.00-kg metal block slides on a rough, horizontal surface inside an insulated pipe. After sliding a distance of 500.0 m, its temperature is increased by 2.00 ºC. **Note**: Assume that all of the heat generated by frictional heating goes into the metal block. For this metal, the specific heat capacity is 0.150 cal/(g · Cº).



How much work does the force of friction do *on* the block?

A) zero joules B) 300 J C) -300 J D) 2510 J E) -2510 J

26. What is the minimum amount of energy required to completely melt a 7.25-kg lead brick which has a starting temperature of 18.0 ºC? The melting point of lead is 328 ºC. The specific heat capacity of lead is 128 J/(kg • Cº); and its latent heat of fusion is 23 200 J/kg.

A) 1.20×10^5 J B) 1.68×10^5 J C) 2.88×10^5 J D) 4.56×10^5 J E) 7.44×10^5 J

27. A household humidifier continuously takes water in at 20.0 ºC at a rate of 5.60×10^{-5} kg/s and heats it until it evaporates. If the cost of electricity is $ 0.14/kWh, what is the daily cost of operating the humidifier?

A) $ 0.31 B) $ 0.49 C) $ 0.58 D) $ 0.65 E) $ 0.70

28. How many moles are in a 0.53-kg sample of sulphur dioxide, SO_2? (atomic masses: S = 32 u; O = 16 u)

A) 5.2 B) 8.3 C) 48 D) 1.6×10^4 E) 5.0×10^{24}

29. A canister containing 115 kg of an ideal gas has a volume of 6.5 m^3. If the gas exerts a pressure of 4.0×10^5 Pa, what is the *rms* speed of the molecules?

A) 260 m/s B) 180 m/s C) 310 m/s D) 390 m/s E) 420 m/s

30. A bubble with a volume of 1.0 cm^3 forms at the bottom of a lake that is 20.0 m deep. The temperature at the bottom of the lake is 10.0 ºC. The bubble rises to the surface where the temperature is 25.0 ºC. Assume that the bubble is small enough that its temperature always matches that of its surroundings. What is the volume of the bubble just before it breaks the surface of the water?

A) 2.1 cm^3 B) 2.8 cm^3 C) 3.1 cm^3 D) 6.0 cm^3 E) 7.7 cm^3

THE END

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(29) $\overline{KE} = \frac{1}{2} m v_{rms}^2 = \frac{3}{2} kT$ (from kinetic theory)

$\Rightarrow v_{rms} = \sqrt{\frac{3kT}{m}}$ where m = mass of one molecule

Ideal gas law: $PV = NkT$ N = number of molecules

$\rightarrow kT = \frac{PV}{N}$

so $v_{rms} = \sqrt{\frac{3PV}{Nm}} = \sqrt{\frac{3PV}{m_{gas}}} = \sqrt{\frac{3(4.0\times10^5 Pa)(6.5 m^3)}{115 kg.}}$

$= \underline{\underline{260 m/s}}$

(don't get hung up confusing m in $\frac{1}{2} m v_{rms}^2$ with m_{gas} :)

(30) $PV = nRT \Rightarrow V = \frac{nRT}{P}$

$\therefore \frac{V_2}{V_1} = \frac{T_2 P_1}{T_1 P_2}$ assuming n does not change.

$\rightarrow V_2 = \frac{T_2 P_1 V_1}{T_1 P_2} = \frac{T_2}{T_1} \frac{(P_{atm} + \rho g h)}{P_{atm}} V_1$

$= \frac{(25+273)}{(10+273)} \frac{(101 kPa + (1000 kg/m^3)(9.8 m/s^2)(2.0 m))}{101 kPa} (1.0 cm^3)$

$= \underline{\underline{3.1 cm^3}}$

Answers

1	A
2	C
3	C
4	E
5	B
6	C
7	A
8	C
9	E
10	A
11	C
12	D
13	B
14	E
15	D
16	C
17	A
18	B
19	C
20	E
21	B
22	A
23	E
24	D
25	E
26	D
27	B
28	B
29	A
30	C